Optimisation of low-fat high-protein cookie formulation: effects of using butter and composite flour on nutritional, physical and sensory properties

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Consumers demand in food products have changed significantly in the last century with lifestyle changes related to new eating habits. Based on the consumers' demand, the food industry and scientists focus on low fat and calorie functional foods that avoid causing nutrition-related illnesses. Therefore, the aim of this study is to develop a low fat-high calorie functional cookie fortified with composite flour (chickpea 50%, whole grain wheat 25% and oat 25%), butter, almond, dried mulberry, egg powder and whey powder. The statistical analyses were carried out by using response surface methodology (RSM). The nutritional (moisture, ash, fat, protein, carbohydrate, and energy content), physical (diameter and thickness measurement, spread ratio) and sensory properties (colour, appearance, taste-odour, texture, overall acceptability, and affordability) of produced cookies were evaluated. The results indicate that the protein content of cookies increased from 13 g/100 g to 24.38 g/100 g with a 9% reduction in fat and calories for the cookies. A cookie containing 15% butter and 15% composite flour has the highest score for overall acceptability and affordability among the cookie samples. The research showed that low fat-high protein cookies fortified by composite flour, with a highly acceptable and nutrition composition can be produced.

Keywords: Butter, Low Fat Cookie, High Protein, Reduced Calorie, Response Surface Methodology

INTRODUCTION

Obesity and overweight have been increasing in many parts of the world [1, 2]. These increases are related with many chronic diseases such as high blood pressure, type 2 diabetes, cardiovascular disease [3-6]. Many studies show that a prevalence of obesity and overweight is associated with eating habits like increasing fat and caloric intake [7-9]. Fat is a necessary nutrient for humans and one of the essential food substances. However, a high fat diet may cause an increasing risk of many health problems [7, 8, 10, 11]. Consumer's awareness of eating healthy increased during the last century in parallel with the increase in diseases related to nutrition [12]. This increasing awareness of consumers has led to understanding that their food choices may have consequences on their health. Moreover, consumers pay more attention to the health benefits of food to maintain a healthy lifestyle. In general, readymade foods consumed by most consumers have a high fat content and a low content of minerals, vitamins, dietary fibres, and proteins. For these reasons, consumers have been tending towards prefering low fat, reduced fat, fat free and functional foods during the last decade [13-15]. One of the biggest challenges today is to improve cheap foods, which have a high nutritional value, and are mostly acceptable by the average customers [16]. Functional food promotes health benefits above normal nutrition. The functional food sector is one of the fastest increasing markets of the food sector

worldwide. This situation can lead to different areas of science providing factories with opportunities to improve various new functional productions [17].
Bakery productions are one of the excellent tools for fortification, value addition and food intake on a mass scale. Currently, the fortification of cookies has evolved to develop its functional and nutritional properties because of the healthy eating awareness of consumers [17-19]. Cookies are consumed ready-made from a high fat bakery production due to the cheapness, acceptable taste, availability, long shelf life and quick release of energy [20]. Fat is a basic ingredient in cookies because it is responsible for flavour, mouthfeel, texture, nutritional and sensory properties [21]. However, cookies are low in, proteins, vitamins, minerals, fibre and rich in undesirable fats, carbohydrates, and calories. Therefore, it is necessary to improve low fat and high nutritional value cookies. In the last decade, researchers and the food industry have focused on the development of the fortification of cookies. It was reported that extruded bean flour was used in cookies to reduce fat, improve nutritional value and sensory properties in the final product [22]. Fortified cookies with vitamins, prebiotic fibres and reduced fat have been accepted by the consumers in terms of colour, flavour and eating qualities [23-25]. Moreover, cookies can be readily fortified with legume flour to increase protein and fibre. The use of mixed flour to improve cookies to develop nutritional values has been reported by several studies [26-31].
Recently, oat has gained the attention of researchers because of a high amount of beta glucan content composites of antioxidant activity and lipid fraction that has a significant impact on the nutritional and technological quality [31-34]. Oats are a good source of beta glucan which reduce the risk of some diseases like diabetes, hypertension, cardiovascular diseases, and obesity [35-41]. Compared to other cereals, oats involve much more fat that is rich in polyunsaturated fatty acids. This fat is unstable, because of the rapid oxidation process so oat productions, for example, oat flakes, oat flour can be used in bakery productions like cookies to improve shelf-life [42, 43]. The addition of oat flour in the cookies can lead to improving protein quality, dietary fibre, shelf life and sensory properties [44].
Chickpea, characterised by the highest nutritional value among all legumes consists of 50% carbohydrates, 17-20% protein, 5-6% of fat, and 3-4% crude fibre [45]. Moreover, chickpea seed is a good source of carotenoids, folic acid, sterols, tocopherols, B-group vitamins, microelements, magnesium, potassium, selenium, zinc, phosphorous. In addition, chickpea has a great digestible plant protein, a complex carbohydrate with a low glycemic index and dietary fibre that can protect against cardiovascular diseases. Using chickpea flour to make bakery products not only raises the mineral and protein content but also contributes to lowering glycemic response in consumers [46, 47]. Studies on the use of chickpea in bakery production have increased in recent years [48-54].
Wheat (*triticum aestivum*) is a nutritionally substantial cereal and a staple food for humans all over the world [55, 56]. It is widely used in bakery productions like pasta, cookies, snacks and crackers due to the valuable properties of the protein (gluten) that combine elasticity and strength to obtain a desirable flavour and texture [55, 57-59]. Consumption of whole grain wheat productions is known to have a beneficial impact on the human body related with their high substance of bioactive phytochemicals, minerals, vitamins, protein, and dietary fibre [60]. It is reported that the consumption of whole grain wheat has positive effects on type-2 diabetes, cancer, obesity, and cardiovascular diseases [61-63]. For this reason, whole grain wheat has attracted attention of customers and of the food industry in recent years [64, 65]. Using whole grain or refined varieties can contribute significantly to a nutritional and functional variation [66-70].
Considering all the above, the purpose of this study is to improve functional cookies that increase protein quality and quantity, dietary fibre, reduce fat and calorie intake with composite flour, oat, chickpea, and whole grain wheat flour.

2. MATERIAL-METHOD

2.1 MATERIALS

Pre-cooked chickpea flour, whole grain wheat flour, oat flour, corn starch, rice flour, butter, almond, dried mulberry, egg powder, whey powder, salt, guar gum, sodium bicarbonate, and ammonium bicarbonate were purchased commercially. All chemicals and reagents were graded analytically.

2.2 METHODS

2.2.1. Determination of the Suitable Mixture and Parameter Ranges for Cookie Production

It is planned to obtain a biscuit formulation with an increased protein quality and quantity by preparing a mixture consisting of pre-cooked chickpea flour, whole wheat flour, oat flour, corn starch and rice flour. As a result of preliminary studies, the mixing ratio of chickpeas, whole wheat grain and oat flour (CWO) was determined as 2:1:1. As a result of preliminary trials, the CWO ratio was determined as 25-100 g/100 g flour and 10-25 g butter as independent variables. Corn starch: rice flour was used at a 1:1 ratio in the productions with a CWO mixture ratio of less than 100 g.

2.2.2. Experimental Design for Cookies Formulation

Designed according to the Response Surface Method, which is an experimental design method. For the optimisation of rich protein and low-fat cookies, experiments were conducted according to a central composite design containing two independent variables that dictated 13 experimental sessions. Independent variables used to determine optimum cookie formulations were CWO and butter content.

The range of upper and lower values of independent variables were 25-100 g/100 g for CWO and 10-25 g for butter was used to optimise and evaluate the impact of independent variables on the dependant variables (Table I).

2.2.3. Cookie Preparation

The production of cookies was carried out by making some changes to the method specified in AACC Method No: 10-54. Cookies were produced by adding rice flour and corn starch (1:1) in the ratio of 0%, 37.5% and 75% to the CWO flour mixture. First, flours and all powder components were mixed to obtain a homogeneous element using a mixer (Kitchenaid, U.S.) for 2 minutes. Then the specified amount of butter was added and stripped every 30 seconds and mixed for 3 more minutes. After that, different amounts of water were added according to the amount of butter and flour specified in the experimental design and the kneading process was completed by mixing for 2 more minutes by stripping every 30 seconds. The obtained dough was placed to rest for 20 minutes and then shaped into discs of a diameter of approximately 50 mm and a thickness of 5 mm. The cookies were transferred to the oven (M4256, Simfer, Kayseri, Turkey) and baked at 180°C for 20 minutes. After baking, the cookies were cooled at room temperature for nearly 30 minutes and then the necessary measurements were made, and the rest of the cookies were ground in a grinder (Premier PRG 259, Istanbul Turkey) and stored in polyethylene containers for further analyses.

2.2.4. Proximate and Nutritional Composition

Crude protein, crude fat, total ash, moisture was determined by employing a standard AOAC analysis method, 1990 [71]. The total carbohydrate and energy content of cookies was calculated by using the following formula [72]:

$$\%\ \text{Carbonhydrate} = 100 - (\text{misture}\ \% + \%\ \text{protein} + \%\ \text{fat} + \%\ \text{ash})$$

$$\text{Energy} = 4\ (\%\ \text{Protein content of cookies} + \%\ \text{carbonhydrate content of cookies}) + (\%\ \text{fat content of cookies}) \times 9$$

2.2.5. Physical Analyses

2.2.5.1. Diameter, Thickness and Spread ratio

The diameter (D) and thickness (T) values of the cookie samples were measured using a vernier calliper as specified in the AACC Standard Method No: 10-54 [73]. After the diameter (mm) and thickness (mm) values of the biscuits, the spread ratio is determined. The spread ratio of the cookies was determined by calculating the ratio of the diameter to the thickness for each sample.

2.2.5.2. Colour Analyses

Colour parameters of cookie samples were measured with a Hunterlab MiniScan EZ (Reston, Virginia, USA), and the values were expressed based on the CIALAB measurement system. White and black calibration tiles were used to standardise the device before analysis. In HunterLab colour scale, L^* (lightness factor 0=black, 100 white); a* (–*a* green, +*a* red); b^* (-*b* blue, +b^* yellow) values were recorded at the daylight (D65/10°) setting.

2.2.6. Sensory Analyses

The sensory evaluation of the cookies was conducted using 10 trained panelists from Hatay Mustafa Kemal University Food Engineering Department. Cookies were coded with three-digit numbers and positioned randomly. The sensory evaluation sheet was provided to the panelist who assessed the colour, appearance, flavour, texture, overall acceptability, and affordability according to their preferences on a 1-5 hedonic scale. According to the scale; 1: bad, 2: not enough,

Table I - Experiment design of independent variables of cookie samples

Independent Variables	Code	-1	0	+1
Butter content (g/100g flour)	X_1	10	17.50	25
CWO (g/100g flour)	X_2	25	62.50	100

Production	X_1	X_2
1	-1.00	-1.00
2	1.00	1.00
3	-1.00	1.00
4	0.00	0.00
5	0.00	-1.00
6	0.00	0.00
7	0.00	0.00
8	-1.00	0.00
9	1.00	-1.00
10	0.00	0.00
11	0.00	0.00
12	0.00	1.00
13	1.00	0.00

3: acceptable, 4: good, 5: very good. All sensory evaluations were conducted at room temperature and water was served to the panellists for mouth cleaning between the sample evaluations [74, 75].

2.2.7. Statistical Analyses

In determining the effects of independent variables on dependent variables, the Central Composite Design of the Response Surface Method was used for the variance analysis. As a result of the variance analysis, significant differences between group means were determined using the SPSS package program. Chemical and physical analyses were performed in triplicate and two replications for the sensory evaluation.

3. RESULT AND DISCUSSION

3.1. PROXIMATE AND NUTRITIONAL COMPOSITION

The result of moisture, ash, fat, protein, carbohydrate, and energy content of cookies are summarised in Table II.

3.1.1. Moisture Content

The result of moisture content of cookies ranged between 10.11% and 13.30%. The moisture content of a production effect on the quality of foods [76]. As it can be seen in Figure 1, the increasing of the ratio of CWO in cookies leads to an increase in moisture content, and this is significant $p<0.01$.

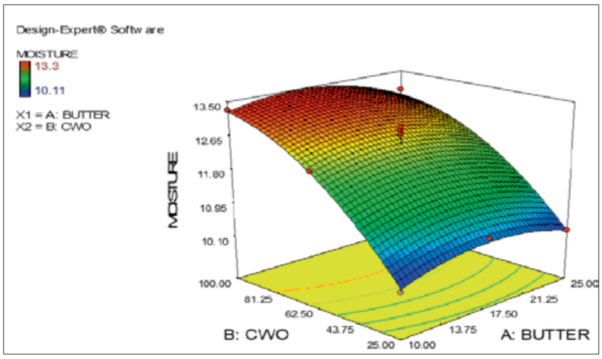

Figure 1 - Response surfaces for the effect of CWO concentration and butter on moisture of cookie samples

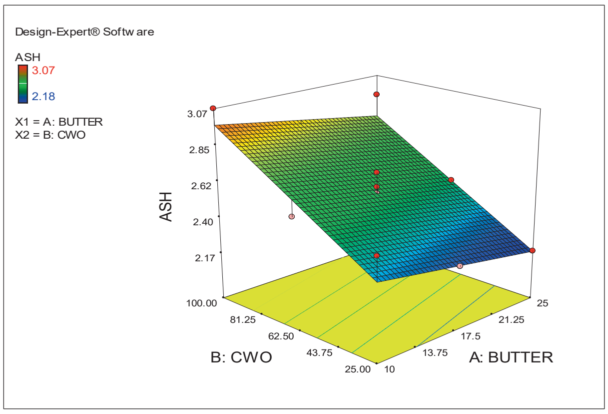

Figure 2 - Response surfaces for the effect of CWO concentration and butter on ash of cookie samples

3.1.2. Ash Content

The value of the ash content of cookies ranged from 2.18% to 3.07%. While sample number 3 has the highest ash value, sample number 9 has the lowest ash content. The response surface plot (Fig. 2) showed that the ash values of cookies increased significantly with the rising of the CWO ratio in the cookies $p<0.01$. A similar result showed that using composite flour increases the ash content of cookies [77].

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3.1.3. Fat Content

Sample number 2 has the highest fat value (19.23%) and sample number 1 has the lowest fat value (11.22%). The response surface plot (Fig. 3) showed that an increased ratio of CWO and butter led to an increase in the fat content in cookies. The fat values of cookies increased slightly with the increasing of the CWO ratio in the cookies $p<0.05$. The fat content of mixed flour was similar, 15.75% [19], 14.1% [78],

Table II - Nutritional properties of low fat high protein cookies

Sample Number	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Carbohydrate (%)	Energy (kcal/100g)
1	10.11±0.01^{a}	2.50±0.00^{d}	11.22±0.07^{a}	13.93±0.10^{b}	62.24±0.18^{g}	406^{b}
2	13.00±0.01^{i}	2.94±0.00^{i}	19.23±0.07^{i}	24.17±0.71^{f}	40.66±0.78^{a}	432^{h}
3	13.30±0.11^{j}	3.07±0.02^{j}	12.70±0.02^{c}	24.38±0.96^{f}	46.55±1.02^{c}	398^{a}
4	12.83±0.01^{h}	2.59±0.00^{f}	14.26±0.02^{d}	18.40±0.21^{d}	51.92±0.17^{e}	410^{d}
5	10.70±0.04^{c}	2.26±0.01^{b}	14.25±0.08^{d}	15.01±0.78^{c}	57.77±0.83^{f}	419^{g}
6	12.23±0.07^{e}	2.55±0.00^{e}	14.85±0.07^{e}	18.35±0.10^{d}	52.02±0.10^{e}	415^{e}
7	12.45±0.05^{f}	2.68±0.02^{g}	15.55±0.11^{f}	18.28±0.76^{d}	51.04±0.91^{d}	417^{f}
8	12.32±0.10^{e}	2.56±0.03^{e}	11.51±0.14^{b}	15.60±0.16^{c}	57.99±0.37^{f}	398^{a}
9	10.26±0.01^{b}	2.18±0.00^{a}	17.02±0.10^{g}	13.00±0.70^{a}	57.55±0.80^{f}	435^{j}
10	12.89±0.04^{h}	2.43±0.01^{c}	14.20±0.00^{d}	18.09±0.66^{d}	52.40±0.70^{e}	410^{d}
11	12.71±0.00^{g}	2.43±0.00^{c}	14.20±0.01^{d}	18.60±0.36^{d}	52.05±0.35^{e}	410^{d}
12	13.29±0.11^{j}	2.79±0.01^{h}	14.20±0.05^{d}	24.27±0.05^{f}	45.45±0.03^{b}	407^{c}
13	12.00±0.18^{d}	2.49±0.02^{d}	18.28±0.05^{h}	20.23±0.54^{e}	47.00±0.69^{c}	433^{i}

$^{a\text{-}j}$ For each parameter. different superscript letters indicate a significant difference ($p<0.01$) among cookie samples

18-22% [79]. Moreover, increasing the butter ratio increases significantly the fat content of cookies p<0.01.

3.1.4. Protein Content

The protein content values varied from 13 to 24.38 g/100 g. The high protein content may be attributed to the presence of chickpea flour. Protein is a significant component that improves the nutrient properties of composite flours [80]. As it can be seen in Figure 4, the increasing in the percentage of CWO in cookies can lead to increasing significantly the protein content in cookies p<0.01. The results of protein content obtained in this study is in close agreement with to rise in protein content using composite flour reported by several studies [77, 81-86].

3.1.5. Carbohydrate Content

The results of the carbohydrate content in cookies ranged from 40.66% to 62.24%. The response surface plot (Fig. 5) shows that the rising percentage of using CWO and butter leads to a significant decrease in carbohydrate content in cookies p<0.01. Similarly, a study on fortified cookies with chickpea and wheat flour reports that the carbohydrate content of cookies ranged from 47.30%-50.03% [77]. Another study reported that increasing chickpea flour can decrease the carbohydrate content [53]. The comparable outcome of the study that used wheat flour in cookies shows that the content of carbohydrates was 44-46% [82]

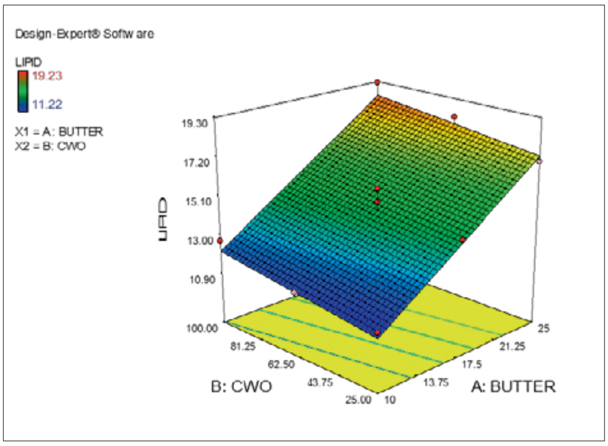

Figure 3 - Response surfaces for the effect of CWO concentration and butter on lipid of cookie samples

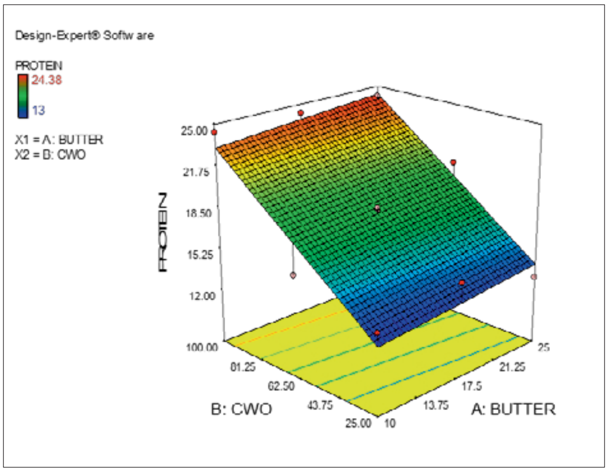

Figure 4 - Response surfaces for the effect of CWO concentration and butter on protein of cookie samples

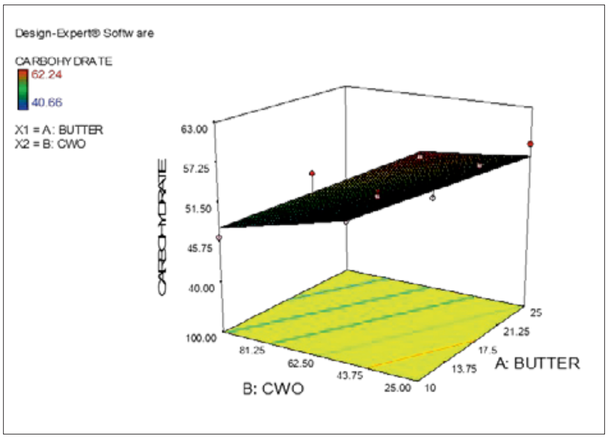

Figure 5 - Response surfaces for the effect of CWO concentration and butter on carbohydrate of cookie samples

Table III – Diameter, thickness and spread ratio values of low fat high protein cookie samples

Sample Number	Diameter	Thickness	Spread Ratio
1	4.74±0.05	0.82±0.04^{h}	5.78±0.33^{a}
2	4.4±0.00	0.52±0.04^{a}	8.46±0.66^{f}
3	4.48±0.04	0.62±0.04^{b,c}	7.23±0.54^{d,e}
4	4.64±0.09	0.7±0.07^{d,e,f}	6.63±0.62^{b,c,d}
5	4.58±0.04	0.78±0.04^{g,h}	5.87±0.30^{a}
6	4.48±0.04	0.6±0.00^{b}	7.47±0.07^{e}
7	4.7±0.07	0.68±0.04^{c,d,e}	6.91±0.51^{c,d,e}
8	4.64±0.05	0.74±0.05^{e,f,g}	6.27±0.45^{a,b,c}
9	4.6±0.00	0.78±0.04^{g,h}	5.90±0.37^{a}
10	4.62±0.08	0.66±0.05^{b,c,d}	7.00±0.59^{d,e}
11	4.66±0.05	0.76±0.05^{f,g,h}	6.13±0.51^{a,b}
12	4.7±0.07	0.68±0.04^{c,d,e}	6.91±0.59^{c,d,e}
13	4.6±0.07	0.78±0.04^{g,h}	5.90±0.45^{a}

$^{a-h}$ For each parameter. different superscript letters indicate a significant difference (p<0.01) among cookie samples

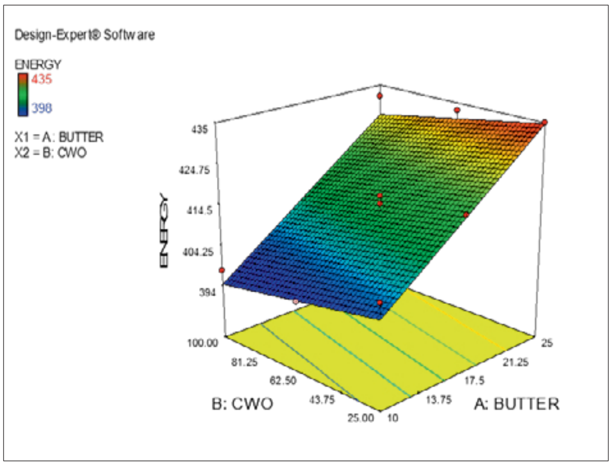

Figure 6 - Response surfaces for the effect of CWO and butter concentration on energy content of cookie samples

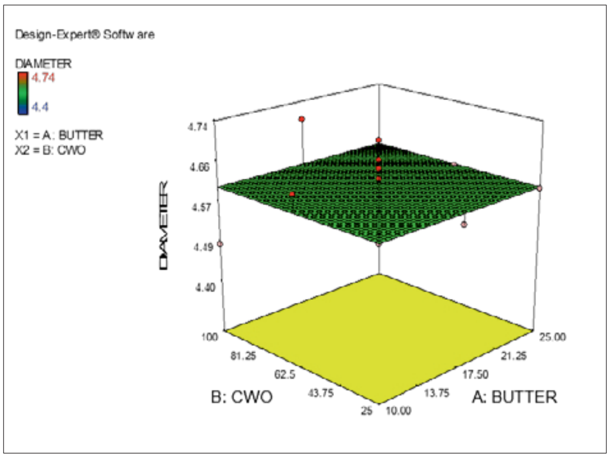

Figure 7 - Response surfaces for the effect of CWO concentration and butter on the diameter of cookie samples

3.1.6. Energy

As it can be seen in Table II the energy content of cookies ranged between 398 and 435 kcal. The response surface plot (Fig. 6) shows that, as the percent of WCO increases in cookies, there was a significant decrease in energy content $p<0.05$. However, the raising of butter ratio in cookies can lead to increase the energy content significantly in cookies $p<0.01$. This finding corresponded to previous studies showing that mixing flours lead to an increase in the energy content [52, 77, 87].

3.2. PHYSICAL ANALYSES

The result of diameter, thickness, spread ratio, and colour of the cookie samples are shown in Table III and Table IV respectively.

3.2.1. Diameter, Thickness and Spread Ratio

The results of the diameter of the cookie samples are given in Table III. Diameter values of cookie samples ranged from 4.40 to 4.70. It can be seen in Figure 7 that the diameters of cookie samples are not affected significantly by the ratio of CWO and butter. While the percentage of CWO in cookie samples affect the thickness of cookie samples significantly, there is no relationship between the percentage of butter in cookie samples and the thickness of cookie samples. As it can be seen in Figure 8, the increasing in the percentage of the CWO in cookie samples can lead to a significant decrease of the thickness $p<0.05$. The value in thickness of the cookie samples shows a significant decrease from 0.82 to 0.52 with an increasing CWO percentage in cookie samples. Spread ratio values of cookie samples ranged from 5.78 to 8.46. The response surface pilot Figure 9 shows that there is a significant effect of the percentage of using CWO on spread ratio in cookies. Nevertheless, the percentage of using butter in cookies does not affect the spread ratio statistically. Spread ratio results showed that, as the concentration of incorporated treatments of whole grain wheat increased, the spread ratio increased significantly $p<0.05$. Higher protein content impacts negatively on the spread ratio in cookies [88]. However, cookies developed by a high percentage of chickpea flour, despite having high protein content, showed a higher spread ratio. This anomalous be-

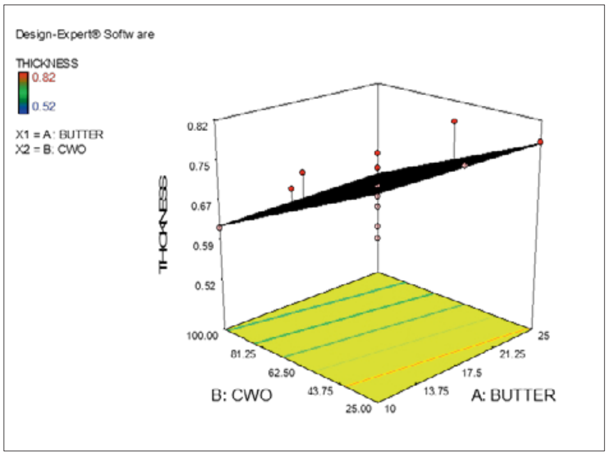

Figure 8 - Response surfaces for the effect of CWO concentration and butter on the thickness of cookie samples

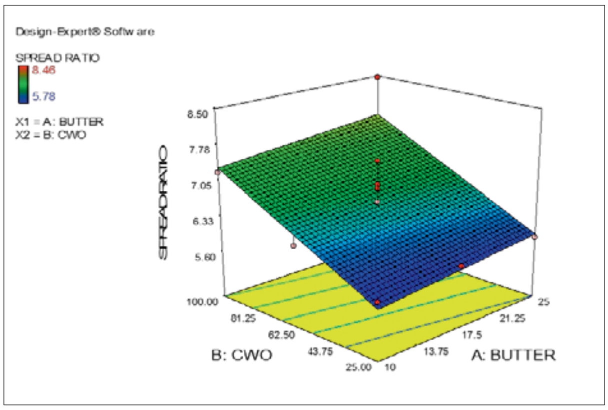

Figure 9 - Response surfaces for the effect of CWO concentration and butter on spread ratio of cookie samples

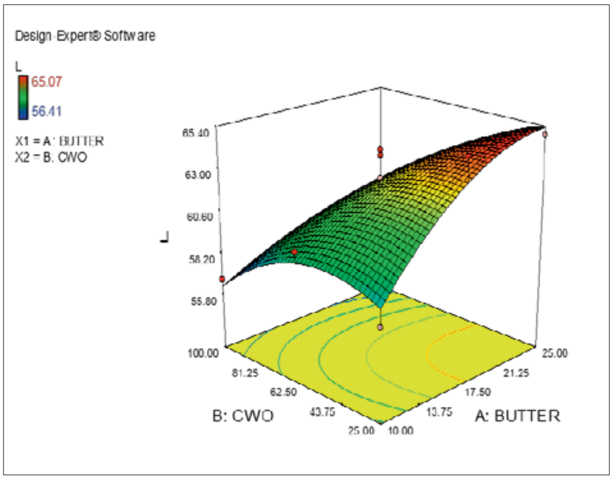

Figure 10 - Response surfaces for the effect of CWO concentration and butter on L value of cookie samples

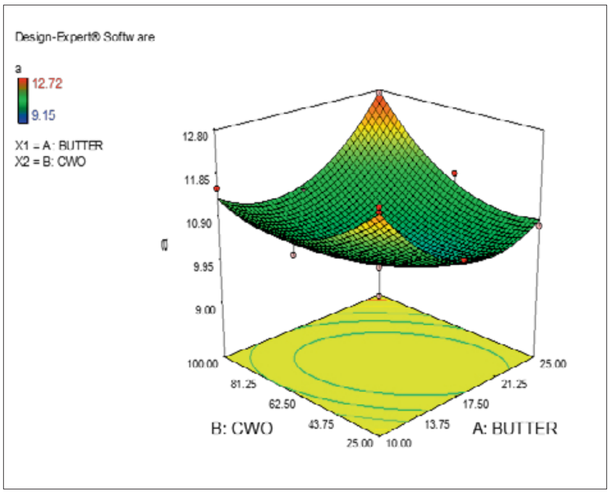

Figure 11 - Response surfaces for the effect of CWO concentration and butter on a value of cookie samples

haviour could be attributed to the reduced viscosity of chickpea dough, and it causes a higher spread ratio. A previous study indicates a decrease in the viscosity of the dough with the addition of chickpea flour [89]. A similar result showed that the lower the viscosity of dough, the faster the spreading rate of cookies [90].

3.2.2. Colour

As it can be seen in Figure 10, the L values of cookies are affected significanlty by the CWO and butter concentration in cookies $p<0.01$, $p<0.05$ respectively. Moreover, the interaction between butter and CWO concentration can impact the L values of cookies statistically $p<0.05$. Increasing the percentage of butter leads to an increase in L values of cookie samples. While increasing CWO concentration up to 65.50 g/100 g in cookie samples leads to an increase in L values, using a CWO concentration above 65.5 g/100g causes a decrease in L values in the cookie samples. As it can be seen from Figure 11, interaction of the butter concentration affects significantly the a values of cookies samples $p<0.05$. Increasing the butter concentration up to 17.50 g/100g gram in the cookie samples leads to a decrease in values of the cookie samples. However, using butter concentrations above 17.50 g/100g causes an increase of b values of cookie samples. The response surface plot Figure 12 shows that increasing the ratio of CWO in cookies led to a significant decrease in the b values of cookie samples $p<0.01$. However, the b values of cookie samples increase significantly by increasing the butter percentage in cookie samples $p<0.01$.

3.3. SENSORY EVALUATION OF COOKIES

Sensory evaluation of cookie samples is summarised in Table V. The scores for colour, appearance, flavour, texture, overall acceptability, and affordability ranged from 2.89 to 4.33, 3.22 to 4.22, 2.33 to 4.33, 2.00 to 4.56, 2.44 to 4.33 and 2.22 to 4.22 respectively based on the panellists assigned for each parameter using a 5- point hedonic scale. There were significant differences between the treatment of fortification of the CWO and butter ratio in cookie samples in terms of colour, flavour,

Table IV - L, a, b values of cookie samples

Sample Number	L	a	b
1	57.83±0.08^{c}	12.32±0.04^{j}	28.03±0.11^{c,d}
2	56.78±0.06^{b}	12.72±0.01^{k}	28.22±0.06^{e}
3	56.67±0.03^{b}	11.55±0.09^{i}	26.68±0.04^{a}
4	64.11±0.11^{j}	9.15±0.00^{a}	27.42±0.02^{b}
5	65.07±0.04^{l}	10.64±0.06^{d}	29.95±0.08^{i}
6	63.81±0.03^{i}	9.80±0.01^{b}	28.31±0.06^{e}
7	62.52±0.01^{h}	9.96±0.24^{c}	28.55±0.13^{f}
8	59.97±0.24^{d}	10.75±0.01^{e}	28.17±0.33^{d,e}
9	64.93±0.06^{k}	10.73±0.02^{d,e}	30.85±0.08^{j}
10	61.13±0.13^{f}	11.03±0.01^{g}	28.91±0.01^{g}
11	60.95±0.06^{e}	10.94±0.01^{f,g}	29.06±0.06^{h}
12	56.41±0.14^{a}	10.92±0.02^{f}	28.01±0.01^{c}
13	62.01±0.06^{g}	11.33±0.06^{h}	30.04±0.09^{i}

$^{a-j}$ For each parameter, different superscript letters indicate a significant difference ($p<0.05$) among cookie samples

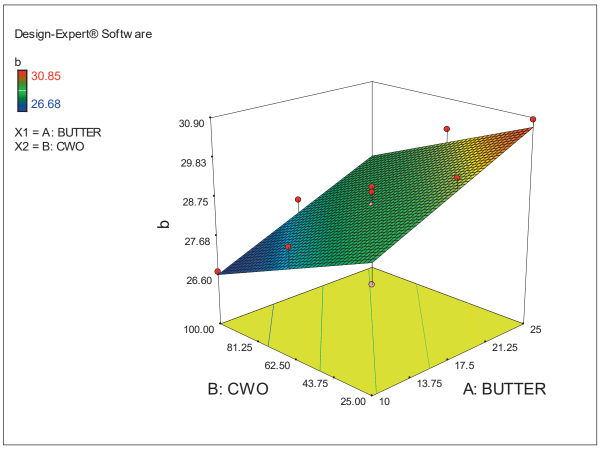

Figure 12 - Response surfaces for the effect of CWO concentration and butter on b value of cookie samples

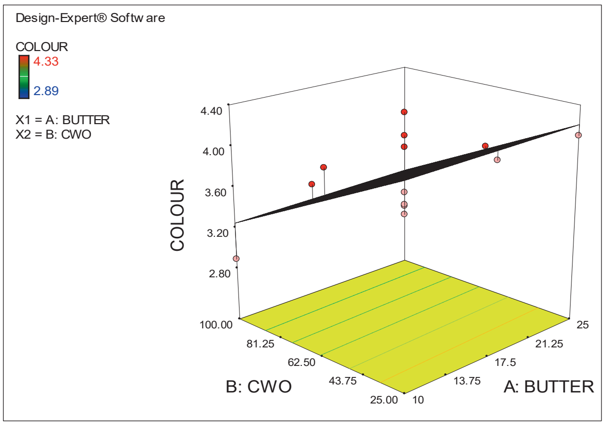

Figure 13 - Response surfaces for the effect of CWO concentration and butter on the score given to the colour of cookie samples

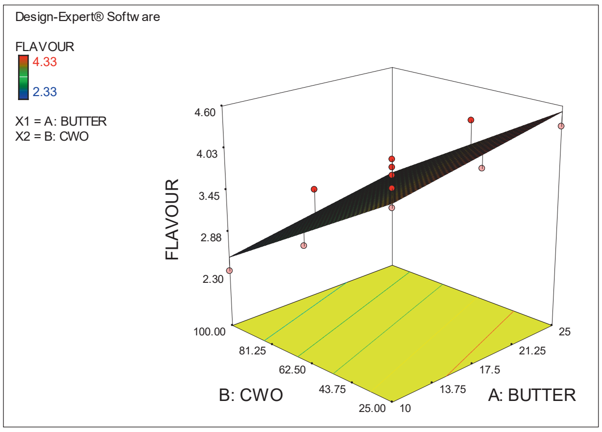

Figure 14 - Response surfaces for the effect of CWO concentration and butter on the score given to the flavour of cookie samples

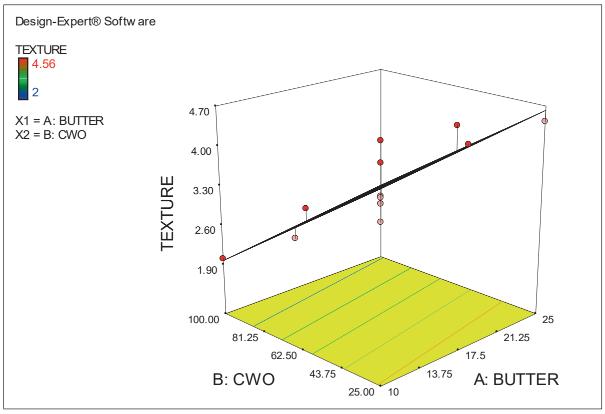

Figure 15 - Response surfaces for the effect of CWO concentration and butter on the score given to the texture of cookie samples

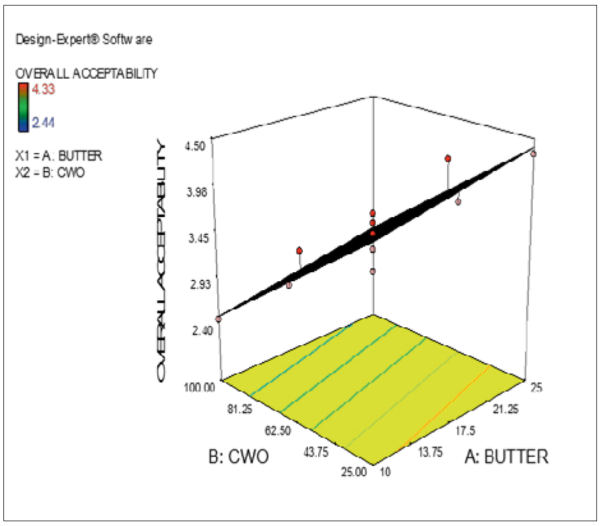

Figure 16 - Response surfaces for the effect of CWO concentration and butter on the score given to the overall acceptability of cookie samples

texture, overall acceptability, and affordability. However, there the statistical results indicate that no differences in appearance were found between cookie samples in terms of the ratio of CWO and butter. As it can be seen from Figure 13, the CWO ratio increased, the score given to colour in the sensory evaluation decreased and this ratio was noticed as statistically significant $p < 0.05$. The response surface plot Figure 14 shows that the increase in the percentage of CWO in cookie samples can lead to a significant decrease in the value of the score given to flavour $p<0.01$. It can be seen in Figure 15 that the scores given to the texture of the cookie samples decreased significantly as the CWO ratio increased. Similarly, as it can be seen in Figure 16, the increase in the CWO ratio in cookie samples affect negatively the score given to overall acceptability and this ratio was noticed as statistically significant $p<0.01$. This effect was noticed as statistically significant. The response surface plot Figure 17 shows that, as the CWO ratio increased, the score given to the affordability by the panellists decreased $p<0.01$. Sample number 9, the highest score for overall acceptability and affordability.

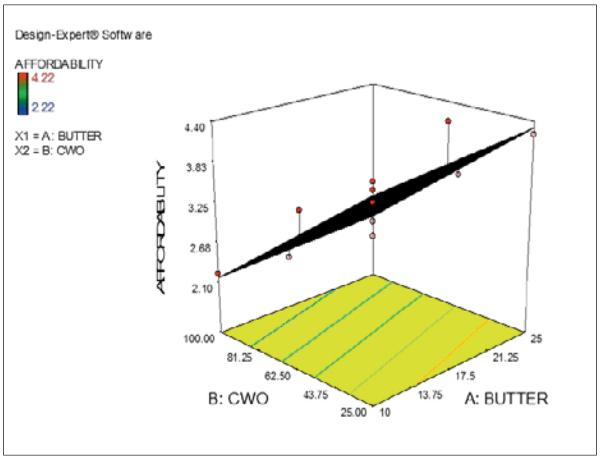

Figure 17 - Response surfaces for the effect of CWO concentration and butter on the score given to the affordability of cookie samples

4. CONCLUSION

The above research shows that composite flour consisting of 32% chickpea, 16% whole grain wheat, and 16% oat flours can be used successfully to replace 100% of the refined wheat flour to formulate healthy low fat high protein cookies having the additional benefit of daily nutrition. Thus, from the results, it may be concluded that cookies high in proteins (nearly 100% increase) and low in calories (nearly 9% decrease) could be made with composite flour. Also from the physical analyses, it may be concluded that cookies are acceptable for their sensory quality. The optimised cookie production chosen by the software was 25% chickpea flour, 12.9% whole grain wheat flour, 12.9% oat flour and 15% butter that give a protein value of 20%. The formulated functional cookies had higher protein content than cookies in literature. The research demonstrated that highly acceptable reduced calorie and high protein cookies, fortified by composite flour, almond, butter, dried mulberry can be produced with a highly acceptable and nutrition composition.

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Notes on Contribute

Neslihan Özbuldu is a doctoral student who get sponsorship from higher education institution (100/2000). She researches on healthy nutrition, healthy life, and food additives.

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Table V - Sensory scores for low-fat high-protein cookie samples

Sample Number	Colour	Appearance	Flavour	Texture	Overall Acceptability	Affordability
1	$3.89\pm0.60^{a.b}$	4.00 ± 1.22	$4.22\pm0.97^{e.f}$	4.56 ± 0.73^{d}	$4.11\pm0.78^{d.e}$	$4.00\pm1.00^{c.d}$
2	2.89 ± 1.05^{a}	3.78 ± 0.83	$2.67\pm1.12^{a.b}$	$2.22\pm0.83^{a.b}$	2.56 ± 0.53^{a}	2.22 ± 0.83^{a}
3	2.89 ± 1.17^{a}	3.22 ± 0.97	2.33 ± 0.71^{a}	2.00 ± 0.87^{a}	2.44 ± 0.73^{a}	2.22 ± 0.83^{a}
4	4.33 ± 0.87^{b}	4.33 ± 0.71	$3.33\pm0.71^{b.c.d.e}$	$3.00\pm0.71^{b.c}$	$3.44\pm0.88^{b.c.d}$	$2.78\pm1.20^{a.b}$
5	4.11 ± 1.36^{b}	3.89 ± 1.36	$4.11\pm0.78^{d.e.f}$	4.44 ± 0.73^{d}	$4.11\pm0.78^{d.e}$	$4.00\pm1.00^{c.d}$
6	4.00 ± 0.71^{b}	4.22 ± 0.67	$3.67\pm0.87^{c.d.e.f}$	$3.00\pm0.71^{b.c}$	$3.44\pm0.73^{b.c.d}$	$3.11\pm0.78^{a.b.c}$
7	$3.56\pm0.88^{a.b}$	3.44 ± 0.88	$3.78\pm0.97^{c.d.e.f}$	4.11 ± 0.78^{d}	$3.56\pm0.53^{b.c.d.e}$	$3.44\pm0.73^{b.c.d}$
8	$3.89\pm0.93^{a.b}$	3.89 ± 1.27	$3.11\pm1.17^{a.b.c}$	$2.89\pm0.93^{b.c}$	$3.22\pm0.97^{a.b.c}$	$2.89\pm1.27^{a.b}$
9	4.11 ± 0.93^{b}	4.11 ± 0.93	4.33 ± 0.71^{f}	4.44 ± 0.88^{d}	4.33 ± 0.87^{e}	4.22 ± 1.09^{d}
10	$3.44\pm1.13^{a.b}$	3.44 ± 0.73	$3.22\pm0.44^{a.b.c.d}$	$2.67\pm0.50^{a.b.c}$	$3.00\pm0.71^{a.b}$	$2.78\pm0.67^{a.b}$
11	4.11 ± 0.60^{b}	3.56 ± 0.88	$3.89\pm1.05^{c.d.e.f}$	3.11 ± 1.05^{c}	$3.67\pm0.71^{b.c.d.e}$	$3.56\pm0.88^{b.c.d}$
12	$3.56\pm1.13^{a.b}$	3.56 ± 1.01	$3.11\pm0.78^{a.b.c}$	$2.44\pm0.73^{a.b.c}$	$2.89\pm0.78^{a.b}$	$2.78\pm1.09^{a.b}$
13	$3.78\pm1.09^{a.b}$	3.56 ± 1.24	$4.11\pm0.78^{d.e.f}$	4.00 ± 0.87^{d}	$4.00\pm0.87^{c.d.e}$	$4.11\pm0.78^{c.d}$

$^{a-f}$ For each parameter, different superscript letters indicate a significant difference ($p<0.05$) among cookie samples

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