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Optimum formulation determination and carbon footprint analysis of a novel gluten-free pasta recipe using buckwheat, teff, and chickpea flours

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Abstract

A gluten-free pasta formulation was developed by buckwheat supplemented with two different gluten-free flours (chickpea and teff) and a natural thickener (xanthan gum). A statistical experimental design was used in three levels and protein values were enhanced with the supplementation of tested flours. The optimum formulation was determined via a multi-criteria decision-making approach in which the weights of the criteria were obtained via an expert survey. The results of the experiments suggested a pasta formulation including 10% chickpea, 5% teff, and 1% xanthan gum, in addition to the buckwheat flour. Once the optimum formulation was determined, the carbon footprint of this formulation was calculated. The results show that the novel formulation has a 33% lower carbon footprint compared to commercial pasta. Findings of this study indicate that the formulation proposed in this paper is beneficial both in terms of human health and environment.

Practical applications

We are proposing a novel pasta formulation, which is not only free of gluten, but also has lower carbon footprint compared to its competitors. Hence, we are targeting an audience of people who would like to reduce their gluten consumption for various health reasons, as well as people who would like to reduce their environmental footprint. This research would be helpful to the industry as it involves a novel pasta formulation, but also to the academy as it uses an original approach of incorporating multi-criteria decision making, statistical analysis, and life cycle assessment methodologies for product quality determination.

1 | INTRODUCTION

Pasta is a globally popular food. Its overall production is of approximately 14.3 million metric tons per year (Cimini, Cibelli, Messia, & Moresi, 2019). Wheat is the main ingredient used in the production of commercial pasta all around the world. However, wheat contains approximately 14% protein, 80%–85% of which is gluten (Han, Ma, Li, Zheng, & Wang, 2019). Gluten is an essential protein for the integration of the dough during pasta production (Carini, Curti, Littardi, Luzzini, & Vittadini, 2013). In contrast to its importance in food processing, it can lead to serious allergic reactions or digestion problems in human body. Consumption of gluten-containing cereals by celiac patients causes absorption problems in the intestines, resulting in insufficient nutrient absorption and intestinal discomfort (Koehler, Wieser, & Konitzer, 2014).

Gluten-free products are often manufactured from wheat-based crops by the removal of gluten protein or utilizing gluten-free grains such as rice and corn. Although these two approaches have been widely used, they either require an additional process for the removal in the former case or serve a lower nutritional value in the final product in the latter case, as the protein content of wheat is higher than those of corn or rice (Hager, Wolter, Jacob, Zannini, &

Arendt, 2012). It is clear that both approaches would increase the environmental impact of the final product per functional unit, assuming that the functional unit is defined as the calorific value of the final product, a common practice when it comes to food products (Cacace, Bottani, Rizzi, & Vignali, 2020). In order to overcome the above-mentioned problems, gluten-free cereals and legumes that naturally contain better nutritional properties, such as, buckwheat, chickpea, teff, quinoa, and sorghum started to gain interest as flour alternatives for the production of gluten-free foods (Lionetti & Catassi, 2011; Naqash, Gani, Gani, & Masoodi, 2017).

In this study, the main ingredient for the pasta formulation was selected as buckwheat which is a protein rich gluten-free pseudocereal (Giménez-Bastida, Piskuła, & Zieliński, 2015; Sanchez, Schuster, Burke, & Kron, 2011). Other ingredients used were teff and chickpea. Teff is an ancient grain with high protein and mineral, and chickpea is a legume which is an important source of fiber (Jukanti, Gaur, Gowda, & Chibbar, 2012; Pagano, 2006). Due to the fact that gluten-free flours require a replacement for gluten protein to obtain dough consistency, xanthan gum was added as a stabilizing agent (Garcia-Ochoa, Santos, Casas, & Go Âmez, 2000).

The method followed in this study begins with the development of a gluten-free pasta formulation utilizing an experimental design methodology with three factors (ingredients) in three levels. The different pasta formulations were tested for optimum disintegration time, protein, moisture, and ash contents together with the requirements of the criteria for the pasta production of Turkish Food Codex. The consistency of the design was approved by validation tests. Once the experimental results were obtained, the optimum formulation was determined by a multi-criteria decision-making approach. Finally, the life cycle carbon footprint of the novel formulation was calculated and compared against that of commercial pasta. Details regarding the experimental design, multi-criteria decision-making analysis, and life cycle assessment methodology can be found in the following sections.

Highlights

- An innovative, gluten-free pasta formulation was developed.
- Buckwheat, chickpea and teff flours, and xanthan gum were used as ingredients.
- Optimum formulation was determined by multi-criteria decision making.
- Buckwheat and 10% chickpea, 5% teff, and 1% xanthan gum are the optimum formulation.
- Carbon footprint of the novel formulation is 67% of that of pasta from wheat.

2 | LITERATURE REVIEW

Together with the awareness toward gluten sensitivity and celiac disease, trends has risen toward the production of gluten-free pasta and noodle from non-gluten, high protein flours including whole ancient grains (Brites, Schmiele, & Steel, 2018), pseudocereals (Biró, Fodor, Szedljak, Pásztor-Huszár, & Gere, 2019; Kahlon & Chiu, 2015; Schoenlechner, Jurackova, & Berghofer, 2005), and legumes (Romero & Zhang, 2019). A study on the comparison of commercial gluten-free pasta with only one ingredient revealed that chickpea pasta had better properties in terms of dietary fiber content and lowering predicted glycaemic index compared to the flours of buckwheat, green peas, and red lentils (Trevisan, Pasini, & Simonato, 2019). The results of another study that used an experimental design for the dough formulation of pseudocereals namely amaranth, quinoa, and buckwheat to produce gluten-free noodles, revealed that the quality of the pasta could be improved with the addition of albumen, emulsifier, enzymes, and xanthan gum. When the performance of the flours was compared, buckwheat showed superior properties in terms of texture firmness and cooking loss (Schoenlechner et al., 2005). There are a few more studies (D'Amico et al., 2015; Larrosa, Lorenzo, Zaritzky, & Califano, 2016; Schoenlechner, Drausinger, Ottenschlaeger, Jurackova, & Berghofer, 2010) reported in the literature using design of experiments as a tool to optimize the production of gluten-free pasta by understanding the effects of protein and water contents on viscoelastic and textural properties (Larrosa et al., 2016) and drying applications on the structure (D'Amico et al., 2015) of the cooked product. The results demonstrated that optimizing key processing parameters successfully increased the quality of the pasta. Several more studies using buckwheat and other pseudocereals such as amaranth and quinoa (Alamprese, Casiraghi, & Pagani, 2007; Alvarez-Jubete, Arendt, & Gallagher, 2009; Biró et al., 2019; Larrosa et al., 2016; Mariotti, Pagani, & Lucisano, 2013; Schoenlechner et al., 2010; Vetrani et al., 2019) also focused on the nutritive value, chemical composition, and the technological challenges on the production of gluten-free pasta and noodles. The improvement of dough rheology resulting in a more cohesive and elastic dough was achieved in a study by Sanguinetti et al. (2015) with the addition of xanthan gum up to 2.5%. Alamprese et al. (2007) also proposed that the addition of gums lets easier workability during rolling on industrial plants. In line with the information provided from the literature it can be concluded that teff, buckwheat, and chickpea flours offer great properties and sensory characteristics. In this context, the dough formulation suggested in this paper is promising to produce high quality gluten-free pasta and replace its gluten-based counterpart.

As far as the studies concerning the environmental life cycle assessment of pasta production are concerned, Fusi, Guidetti, and Azapagic (2016) assessed the environmental impacts of the catering sector in Italy, by focusing on the case of pasta. They used ReCiPe methodology and SimaPro software for impact calculation. They considered the cooking, cool chain, warm chain, and transportation stages within their system. Their results showed that the cool chain is responsible for most of the impacts and the authors suggested that the environmental impacts of pasta cooking could be reduced by gas rather than electric appliances. Cimini et al. (2019) investigated the cooking quality and the carbon footprint of short-cut extruded pasta as a function of water-to-pasta ratio. They found out that it was possible to cook 1 kg of short pasta with just 3 L of water under mild mixing with a minimum energy need of 0.54 Wh/g, thereby cutting the greenhouse gas emissions caused by dry pasta consumption by approximately 50%. Hess, Chatterton, Daccache, and Williams (2016) estimated the blue water scarcity footprint and greenhouse gas emissions associated with the production, manufacture, and distribution of three popular starchy carbohydrate foods as consumed in the United Kingdom, one of which is dried pasta. Results showed that approximately 50% of the carbon footprint of pasta comes from primary production, 30% comes from processing and packaging, whereas the remaining 20% comes from transportation and distribution. When compared to other starchy foods, pasta was found to have lower carbon footprint than basmati rice but a higher carbon footprint than potatoes. Ruini, Marino, Pignatelli, Laio, and Ridolfi (2013) calculated the footprint of a 1 kg product of a well-known commercial pasta producer. They found out that the water footprint of 1 kg of pasta ranges between 1.336 and 2.847 L of water, depending on the production site, local environmental conditions, and agricultural techniques used to cultivate wheat. Finally yet importantly, Heidari et al. (2017) performed a comprehensive life cycle assessment of pasta production in Iran. They investigated the impacts on terrestrial biodiversity caused by climate change, ecotoxicity, acidification, land use, photochemical ozone formation, and water use were assessed for pasta production from durum wheat on 90 farms in Iran. They used ReCiPe endpoint methodology alongside SimaPro software. Their main finding was that the agricultural stage causes the highest amount of environmental damage and largest variability.

The review of the previous literature shows that the particular combination of ingredients used in this study is novel as far as gluten-free pasta production is concerned. The application of methods such as multi-criteria decision-making and life cycle assessments are further strengths of this paper. The findings reported in this paper are expected to benefit all the stakeholders of gluten-free pasta production at local and global levels.

3 | MATERIALS AND METHODS

This section provides information on the experimental design method employed for pasta production, the multi-criteria decision-making approach used to determine the optimum formulation, and the life cycle assessment method used to determine the carbon footprint of this formulation.

3.1 | Development of a novel pasta formulation

3.1.1 | Materials

Buckwheat flour, teff flour, chickpea flour, and xanthan gum used in this study were purchased from Global Gıda (Konya, Turkey), Nustil (İstanbul, Turkey), Global Gıda (Konya, Turkey) and Tito Gıda (Turkey), respectively. Pasta doughs were shaped to maccheroni using a laboratory-scale pasta press (Regina Wellness, Marcato, Italy).

3.1.2 | Experimental design

Box–Behnken RSM with three factors and three levels was applied to evaluate the effect of teff flour (X1), chickpea flour (X2), and xanthan gum (X3) on specified quality properties of pasta which are protein, ash, moisture, and disintegration time (DesignExpertv11.0, 2020). The factors, levels, and distribution of the experimental design in terms of actual values as 15 combinations are shown in Table 1. All the percentages in Table 1 are given with respect to the

TABLE 1 Units, levels, and mass (added to 50 g of buckwheat) of the independent variables used in Box–Behnken experimental design

Run/Factors	Teff flour%	Chickpea flour%	Xanthan gum%	Teff flour (g)	Chickpea flour (g)	Xanthan gum (g)
1	10	10	0.5	5	5	0.25
2	5	10	0	2.5	5	0
3	5	0	0	2.5	0	0
4	0	5	0	0	2.5	0
5	5	5	0.5	2.5	2.5	0.25
6	5	5	0.5	2.5	2.5	0.25
7	0	5	1	0	2.5	0.5
8	10	5	1	5	2.5	0.5
9	0	10	0.5	0	5	0.25
10	5	10	1	2.5	5	0.5
11	10	5	0	5	2.5	0
12	5	0	1	2.5	0	0.5
13	5	5	0.5	2.5	2.5	0.25
14	0	0	0.5	0	0	0.25
15	10	0	0.5	5	0	0.25

amount of buckwheat used. For example, if a formulation contains 50 g of buckwheat and if the teff flour content is 5%, then that sample would contain 50 × 0.05 = 2.5 g teff flour.

3.1.3 | Pasta processing

About 50 g buckwheat flour was mixed with 70 ml of boiled water and was used to homogenously knead the flour. The addition of hot water disrupts the starch molecules and elastic starch paste properties are created with the close packing of swollen starch granules (Yoo, Kim, Yoo, Inglett, & Lee, 2012). Following, the dough was let to chill for 24 hr in order to fully complete the absorption of water. Teff flour, chickpea flour, and xanthan gum were added in varying percentages of the constant weight of buckwheat suggested by Box–Behnken RSM (Table 1). Before each use, the xanthan gum contents determined by the experimental design were mixed and homogenized with about 5 ml of warm water at 40°C by adjusting the amount of water. Each dough formulation was manually kneaded thoroughly for 15 min. Pasta doughs were shaped using a laboratory-scale pasta press, as indicated above. Extruded pasta samples were dried for 4 hr by gradually increasing the temperature from 60°C to 100°C with 20°C intervals in three incremental steps. The moisture content was measured once at the end of the 4-hr drying period. The finished uncooked samples were not observed to have surface cracks or any other morphological inadequacies. The images of the cooked pasta samples are shown in Figure 1.

3.1.4 | Basic analyses of pasta (moisture, protein, ash content, and disintegration time)

Previously weighed samples (about 3 g) were dried for 3 hr at 105°C, following, the samples were cooled down in a dessicator and the calculated difference in weight was divided by the initial weight of the samples. Moisture content is reported in percentage using the formula described by AOAC (Method No: 926.07, 1999).

Total protein content was determined in terms of nitrogen content using a classical Kjeldahl (Velp Scientifica, Italy) method with a conversion factor of 6.25 specified for “other products in cereals and legumes” according to the manual provided by the certified distributor company (Tetra Technological Systems Inc., Turkey). The total mineral content of uncooked pasta was determined according to Marshall (2010). About 2 g of finely ground pasta was weighed, and 2 ml of distilled alcohol was placed in the crucibles and burnt. After the flames were switched off, and the samples were burnt for 4 hr at 850°C in an calcination furnace. Following the completion of incineration, the crucibles were removed and cooled in a desiccator for an hour, weighed, and finally the ash content was calculated in percentage. Each dough formulation was tested for cooking integrity. An adaptation of the method by Menga et al. (2017) by only calculating the disintegration time as the duration until which pasta samples started to disintegrate regardless of testing its firmness analytically was used. Accordingly, the disintegration time was determined by cooking 2.5 g pasta samples in 100 ml of boiling water until they lost their maccheroni shape (Figure 1).

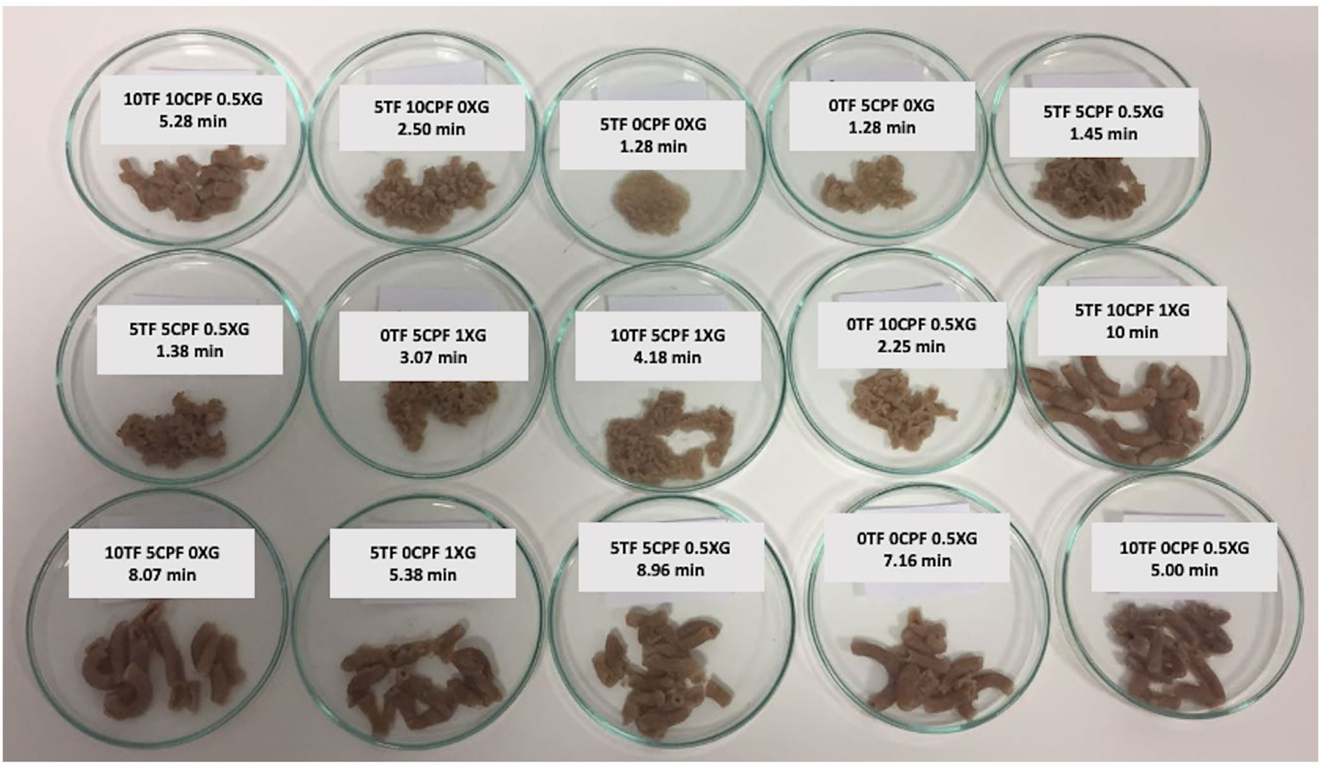

FIGURE 1 Images of dried and cooked pasta samples

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Design Expert 11 and Microsoft Excel software were used to conduct the statistical analyses of the formulations.

3.2 | Determination of the optimum formulation via multi-criteria decision making

While ash and moisture contents are important parameters as far as the quality of pasta from a Turkish Food Codex point of view is concerned, the parameters considered in this study to define the product quality from a consumer point of view are the protein content and pasta disintegration time. Disintegration duration of the pasta is an important parameter that defines the quality of the final product (Cubadda, Carcea, Marconi, & Trivisonno, 2007) whereas the protein content is a critical indicator of the healthiness of pasta. Therefore, the overall quality of the product was defined with respect to these two parameters. To determine the weights, a total of 75 food engineers in the authors' professional network were contacted and asked to choose between these two parameters. Forty-eight of these food engineers are academics and 27 of them work in the private sector. A survey score of 1 was given to a particular parameter each time it was chosen by a participant and the other parameter was given a survey score of 0. The next step was to calculate the weight of each parameter by dividing the total survey score of each parameter by the total number of participants. This step was followed by the calculation of the overall score of each run tabulated in Table 1, as described below:

$$OS_i = PC_i \times W_{PC} + DT_i \times W_{DT} \tag{1}$$

where "i" is the run (formulation) index, OS_i is the overall score of formulation i, PC_i is the normalized protein content of formulation i, W_{PC} is the weight of protein content, DT_i is the normalized disintegration time of run i, and finally W_{DT} is the weight of disintegration time. Normalization method can be found elsewhere (Abdi, 2010). The optimum formulation was obtained as the one that yielded the highest OS_i value.

3.3 | Life cycle assessment

Life cycle assessment (LCA) is an effective tool for evaluating a product's environmental burden by quantifying the impacts of all inputs and outputs associated with corresponding production processes (Uctug & Azapagic, 2018). The methodological guidelines of LCA are laid out in the ISO 14040 and ISO 14044 standards (ISO, 2006a, 2006b). In this study, CCaLC2 LCA software (CCaLC, 2018) was used to model the system and estimate the global warming potential (GWP) of the novel gluten-free pasta formulation according to the CML 2001 method. The carbon footprint of chickpea was already available in CCaLC library, which uses Ecoinvent database; whereas data regarding the other inputs (teff flour, buckwheat flour, xanthan gum, energy required for milling, energy required for pasta production) were adopted from elsewhere (ams.usda.gov, 2016; Heidari et al., 2017; Jungbunzlauer, 2017; Xu, Xu, Peng, Yang, & Zhang, 2018). Carbon footprint of the electricity consumed for the production processes was adopted from another study, which focuses on the LCA of electricity generation in Turkey (Atilgan & Azapagic, 2016). The functional unit was defined as 1 kg of novel pasta. Raw material supply, production, packaging, and transportation stages were considered in the model.

4 | RESULTS AND DISCUSSION

4.1 | Analysis of pasta formulations

The results of the experiments are tabulated below.

In addition to the data shown in Table 2, ash content and moisture contents of the pasta formulation were obtained as 1.7 ± 0.3% and 8.1 ± 1.3%, respectively. The evaluation of each run for protein, ash and moisture contents revealed that all pasta formulations meet the criteria of Turkish Food Codex (Istanbul Provincial Health Directorate, 2002). As expected, formulations that contain higher amounts of teff and chickpea flour have higher protein contents whereas increasing the concentration of xanthan gum improves the adhesion between the ingredients and consequently increases the disintegration time. Moreover, the last ingredient xanthan gum was reported to have important technological properties to replace gluten protein in pasta production such as compatibility with food ingredients and strong thickening ability (Garcia-Ochoa et al., 2000). Accordingly, when xanthan gum was not added to the dough, pasta disintegrated very quickly resulting in a very short time until disintegration; moreover, as reported in the literature, when the gum percent in the dough was increased to 1%, the pasta was stable for a longer disintegration time.

4.1.1 | Statistical analysis

The average values for protein content and disintegration time were found as 13.6% and 4.5 min, respectively, whereas the relative standard deviations for protein content and disintegration time were found as 6.2% and 65.7%, respectively. While the former value is acceptable, a relative standard deviation of 65.7% was considered to be too high. When the results were investigated more deeply, it has been observed that formulation #11 was not consistent with the rest. This particular formulation contains no xanthan gum, hence the disintegration time was expected to be short. However, the third highest disintegration time value (8.1 min) belongs to formulation #11. Formulation #13 also was not in agreement with the rest of the data. Formulation #13, alongside formulations #5 and #6, is what is called the middle point in Box–Behnken experimental design (the experimental design involved three factors at three levels. 0% for all ingredients is the lower level, the higher level for chickpea and teff flours is 10%, whereas the higher level for xanthan gum is 1%, meaning that the middle point would have a composition of 5%

Run	Teff flour (%)	Chickpea flour (%)	Xanthan gum (%)	Protein content (%)	Disintegration time (minutes)
1	10	10	0.5	15.1	5.2
2	5	10	0	14.2	2.5
3	5	0	0	12.0	1.3
4	0	5	0	12.7	1.3
5	5	5	0.5	13.6	1.5
6	5	5	0.5	12.3	1.4
7	0	5	1	14.0	3.1
8	10	5	1	13.9	4.2
9	0	10	0.5	14.5	2.3
10	5	10	1	14.3	10.0
11	10	5	0	14.2	8.1
12	5	0	1	13.3	5.4
13	5	5	0.5	13.3	9.0
14	0	0	0.5	13.7	7.2
15	10	0	0.5	13.3	5.0
Mean				13.6	4.5
SD				0.84	3.0
Relative *SD* (%)				6.2	65.7

TABLE 2 Protein content and disintegration time values of different formulations

chickpea flour, 5% teff flour, and 0.5% xanthan gum). When the protein contents and disintegration times of these three formulations are compared, it can be seen that the protein contents are in good agreement whereas the disintegration time of formulation #13 is significantly different from the disintegration times of formulations #5 and #6. Therefore, the response values associated with formulation #11 and formulation #13 were considered to be indeterminate experimental errors.

Although certain trends in regards to the effects of the factors on the responses have been discussed in Section 4.1, analysis of variance (ANOVA, $p < .05$) showed that the protein content is significantly affected by chickpea flour concentration. Other two ingredients were found not to have a significant effect on the protein content whereas none of the ingredients was found to significantly affect the disintegration time. Removing the data belonging to formulations #11 and #13 from the dataset did not change this outcome.

Finally, the optimization feature of Design-Expert software revealed that the following combination would return the highest protein content and highest disintegration time: 10% chickpea flour, 10% teff flour, and 0.62% xanthan gum. This particular combination would yield a protein content of 15.1% and a disintegration time of 7.6 min.

4.1.2 | Determination of the optimum formulation

The second step in the multi-criteria decision-making methodology after obtaining the criteria scores is the determination of the weights, as explained in Section 3.2. The results of the weight calculation step are shown in Figure 2. As shown in Figure 2, 62% of the participants suggested that the protein content should be the main parameter to consider, while assessing the quality of pasta products developed in this study.

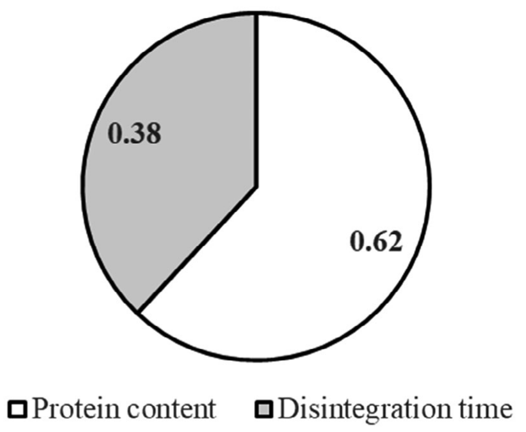

FIGURE 2 Weights for formulation indicators

By combining the data shown in Table 2 and Figure 2 according to Equation (1), the overall scores of each formulation (run) were found as follows:

As shown in Figure 3, the optimum formulation is obtained as formulation #10, which contains buckwheat + (5% teff flour, 10% chickpea flour, 1% xanthan gum). As indicated in Section 4.1.1, increasing the teff flour fraction to 10% is likely to further increase the protein content. However, "10% teff flour, 10% chickpea flour, 1%

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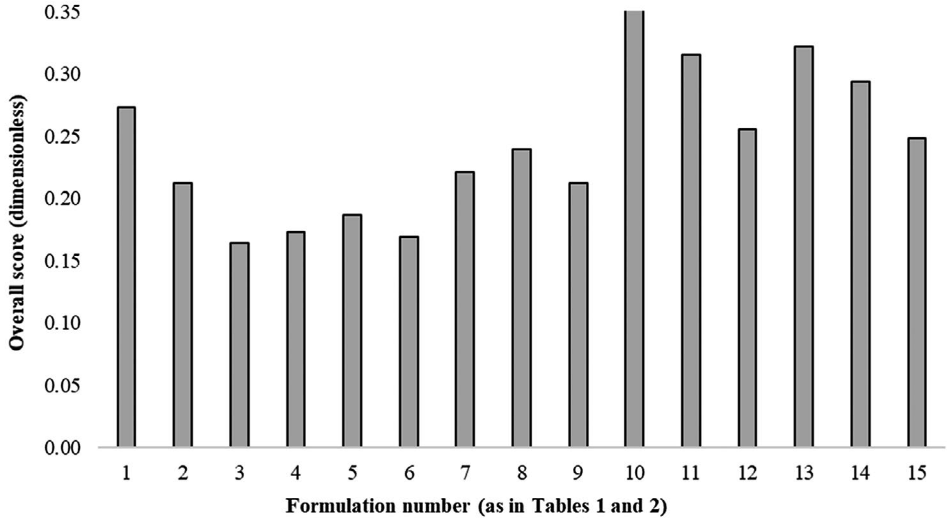

FIGURE 3 Overall scores of different formulates

TABLE 3 Life cycle inventory data

Input/Process	Unit	Quantity	Stage	References
Buckwheat flour	kg	0.86	Pasta production	Xu et al. (2018)
Chickpeas	kg	0.086	Pasta production	Ecoinvent (CCaLC library)
Teff flour	kg	0.043	Pasta production	Xu et al. (2018)
Xanthan gum	kg	0.0086	Pasta production	ams.usda.gov (2016), Jungbunzlauer (2017)
Drinking water	kg	1.20	Pasta production	Heidari et al. (2017)
Process electricity	MJ	0.859	Pasta production	Heidari et al. (2017)
Drinking water	kg	5.0	Cooking	Arrieta and González (2019)
Heat, natural gas	MJ	1.80	Cooking	Arrieta and González (2019)
Recycled polyethylene	kg	0.01	Packaging	–
Lorry transportation, gasoline	km	200	Transportation	–

xanthan gum" would be an extreme point, which is not considered in the Box–Behnken method, similar to the other extreme point of "0% teff flour, 0% chickpea flour, 0% xanthan gum," or simply pure buckwheat flour.

4.2 | Environmental impact analysis

The life cycle assessment of the novel gluten-free pasta developed in this study was conducted based on formulation #10. Data regarding raw material supply were acquired from Ecoinvent database whereas the energy required for the cooking was obtained from the literature (Arrieta & González, 2019). Prior to presenting the carbon footprint calculations, the life cycle inventory of the pasta production process should be provided. Calculations were realized according to the quantities tabulated in Table 3.

The results of the environmental life cycle analysis are shown in Figure 4.

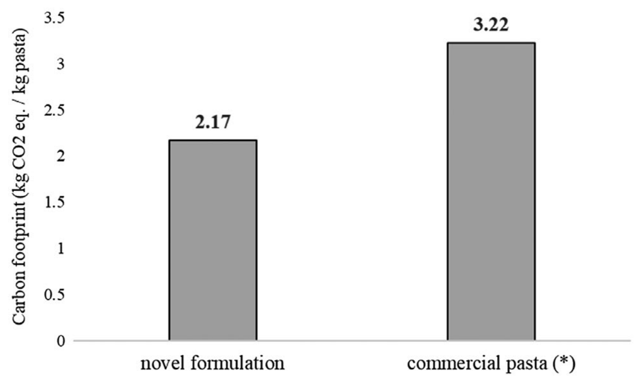

FIGURE 4 Lifecycle carbon footprint of our formulation and commercial pasta. (*) mean value of seven different entries available in the CCaLC database was taken

As shown in Figure 4, the novel formulation proposed in this study has a 33% lower carbon footprint than commercial pasta. Therefore, this particular formulation of pasta is not only beneficial from a health point of view due to being gluten-free, but it is also environmentally friendly compared to its conventional alternatives. The main contributor to carbon footprint of the novel formulation was buckwheat flour and teff flour. Raw material supply was responsible for more than 85% of the overall carbon footprint, followed by the production stage who was a contribution of 11%.

5 | CONCLUSION

In conclusion, this work suggests a novel dough formulation for the production of gluten-free pasta with enriched protein content. The evaluation of the product quality revealed that the new product meets the quality criteria of pasta production for cooking, moisture, ash, and protein. By combining chickpea flour, teff flour, and xanthan gum in addition to buckwheat with the developed formulation, dough matrix was improved, and protein content was fortified significantly. Protein content was found to be significantly affected by the chickpea flour fraction in the formulation.

The dough formulation developed in this study with health benefits and lowered carbon footprint is a promising alternative to traditional pasta. Further studies are suggested to focus on the production of this specialty pasta formulation in an industrial scale keeping in mind the sensory attributes, starch structure, and processing conditions to introduce a commercially desired gluten-free product to the market. An economic life cycle analysis can also be considered. The valuable outcomes of this study stand as a useful guide for further recommended studies.

CONFLICT OF INTEREST

The authors have declared no conflicts of interest for this article.

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