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Optimisation of a process for cocoa-based vermicelli

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Abstract: Due to its health promoting properties owing to a high phenolic content and sensory acceptability, cocoa has gained interest as an additive of choice in many food products. The purpose of this study was to incorporate cocoa powder (CP) in vermicelli. Different proportions of cocoa powder (5, 10, 15 and 20%) were prepared by mixing it into a blend of wheat flour and rice flour (60:40) as base ingredients. The quality parameters, including nutritional characteristics, antioxidant activity, cooking and functional properties, and sensory acceptability, were studied. The nutritional profiling showed a significant ($p < 0.05$) increase in the protein, fat, ash, and carbohydrate alongside a significiant decrease in the moisture content. Similarly, an antioxidant activity increased significantly at $p < 0.05$, with the increase of cocoa powder concentration. It can be concluded that vermicelli with the 10% cocoa powder incorporated was the best treatment since it was rated as the highest in overall acceptability compared to the other formulations. The bulk density, cooked weight, cooking time, gruel solid loss, and water absorption capacity of samples with 10% cocoa powder were 0.714 g/cm^3, 11.56 g, 7.21 min, 0.47 g/100 g, and 146%, respectively. The energy value of the optimised cocoa-based vermicelli was 375 kcal/100g of sample.

Keywords: Cocoa powder, antioxidant, vermicelli, nutritional profiling, cooking properties

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INTRODUCTION

Cocoa beans nave relatively high polyphenolic content and high antioxidant activity. Flavanol monomers, epicatechin and catechin, along with the procyanidins, are the major phenolic phytochemicals present in cocoa [1]. Cocoa and its various products have become an area of interest as they have health-stimulating properties. Cocoa and its derivative products, Such as dark chocolate, cocoa liquor, and cocoa powder, showed remarkable changes in suppressing atherosclerotic lesions and increased dermal blood flow. The phenolic properties of cocoa, especially flavonoids, help in suppressing the multiplication of human breast cancer cells [2]. Cocoa consumption improves the lipid profile, insulin sensitivity, and blood pressure [3]. Cocoa powder is added in the preparation of *shrikhand* [4], biscuits [3], and cakes [5]; however, no study has been reported for its incorporation in vermicelli.

Vermicelli is one of the most popular instant food products. Vermicelli comes in the category of extruded products and is prepared from the whole or refined wheat flour. It is a snack food item liked by all age groups and groups with changing lifestyles. Instant food items have gained popularity and have become the source of mass consumption [6]. Vermicelli is basically judged by uniformity, cooking, as well as eating quality. Cooking, sensory, and nutritional qualities are major attributes of vermicelli.

The present study was therefore undertaken to formulate vermicelli enriched with cocoa powder, using wheat flour and rice flour as the base material. Physical, antioxidant, cooking, and sensory properties were studied.

STUDY OBJECTS AND METHODS

Materials. Cocoa powder (Weikfield premium cocoa powder, Loni, Pune, Maharashtra, India) was procured from the local market of Phagwara, Punjab. The commercial wheat flour and rice flour were procured from the flour mill of a local market of Phagwara, Punjab.

Methods. Preparation of the blend. A preliminary investigation was carried out by preparing base flours in different ratios of wheat flour and rice flour, of which 60 : 40 proportion ensured proper binding during the cocoa incorporation. This blend became the base flour. The base flour was mixed with cocoa powder in different proportions to make the treatments. The vermicelli samples were prepared using 95:5 (CP_1), 90:10 (CP_2), 85:15 (CP_3), and 80:20 (CP_4) proportions of the base flour and cocoa powder, respectively; the base flour was used as a control. The flours were sieved using a sieving machine (Flour Tech Engineers Pvt. Ltd., Faridabad, India) with particle sizes of 63, 80, 100, 125? and 140 µm and 200 mm diameter sieves. The flours with the moisture content of 5% were stored in zip sealed polyethylene pouches (Wellworth Packers Pvt. Ltd., Delhi, India) until further use.

Vermicelli preparation. The standard vermicelli preparation process described by Devi et al. [7] was adapted. On the basis of the texture and consistency of the pre-experiment sample, 5 different compositions with the blend of rice and wheat flours were prepared for experiments. Hard dough was prepared by mixing wheat flour, rice flour, and cocoa powder in different compositions (0, 5, 10, 15, and 20%). Distilled water (60 ml) was added slowly and kneaded into a homogenous soft dough. The dough was prepared using a traditional cold extruder (Siddhmurti kitchen press, India) The obtained vermicelli samples were dried at 60 ± 2°C for an hour in a tray drier; the dried vermicelli was packed in zip pouches for further use. The process flow chart for the preparation of vermicelli is shown in Fig. 1.

Nutritional profiling of cocoa vermicelli. The nutritional profiling of the optimised vermicelli, which includes moisture, carbohydrates, protein, total minerals (ash), and fat content, was determined by standard AOAC procedures [8]. The energy value was determined by Bomb Calorimeter, Labtronics, Model LT-1160 (Bombay Scientific, Ambala, Haryana, India).

Antioxidant activity. Antioxidant activity (free radical scavenging activity) was measured using the method described by Rasane et al. [9]. DPPH (2, 2-diphenyl-1-picrylhydrazyl) was used as a source of free radicals. The concentration of the DPPH solution used was 90 µol/L, the DPPH solution was diluted in 2.9 ml of ethanol, and 0.1 ml of the extracts at various concentrations was added. After shaking the mixture well, it was kept for 60 min in dark and then the absorbance was measured at 517 nm against the blank. The antioxidant activity was calculated using the following equation:

$$\text{Antioxidant activity (\%)} = \frac{A_{control} - A_{Sample}}{A_{control}} * 100,$$

where

$A_{control}$ = Absorption of the DPPH solution

A_{sample} = Absorption of the sample

Cooking and functional properties of cooked vermicelli. The bulk density was calculated by transferring 10 g of the sample into 50 ml of the graduated measuring cylinder. The sample was packed with gentle tapping the cylinder on the flat table at least for 10 times from a height of 5 cm. The volume of the sample was recorded by using the formula given by AOAC 2000 [8]:

$$\text{Bulk density} \left(\frac{\text{g}}{\text{ml}}\right) = \frac{weight\ of\ the\ sample}{volume\ of\ the\ sample\ after\ tapping}$$

The water absorption was calculated by using the methods described by [10]. The formula used was:

$$\text{WAC} = \frac{Weight\ of\ centrifuge\ tube + weight\ of\ sediment - weight\ of\ empty\ tube}{Weight\ of\ sample}.$$

Cooking time was estimated using the method described by Singh et al. [10]. A sample of 10g was cooked in 200 ml of boiling water until the disappearance of white core and judged by squeezing it between two slides. The resulted time was noted as cooking time. Cooking loss was calculated by using the method described by Aydin and Gocmen [11]. The water uptake percentage was determined by using the method described by Ma et al. [12]. The difference in the cooked and uncooked samples of vermicelli was calculated and expressed as the weight of the uncooked sample in percentage.

Sensory evaluation of noodles. The vermicelli samples (formulated and control) were cooked in milk with a small amount of sugar. The prepared vermicelli was analysed for its sensory properties by 50 semi-trained panellists (25 men and 25 women at the ages of 20–35 years). The parameters used were colour and appearance, flavour (taste and aroma), texture, and overall acceptability. Nine point hedonic scale was used for sensory evaluation of the vermicelli samples. The samples freshly cooked in milk and sugar were served in an odourless plastic container, in a separate chamber. The panellists were served with one sample at a time at an interval of 2 min in between two samples. Potable water was also served at room temperature to rinse mouth in between samples.

Statistical Analysis. All the data were obtained in triplicate and presented in mean ± standard deviation. One Way Analysis of Variance (ANOVA) followed by Duncan's Multiple Range test and the Post hoc test was used to analyse the data using the SPSS 22.0 software (SPSS Italia, Bologna, Italy) at the error level of 5%.

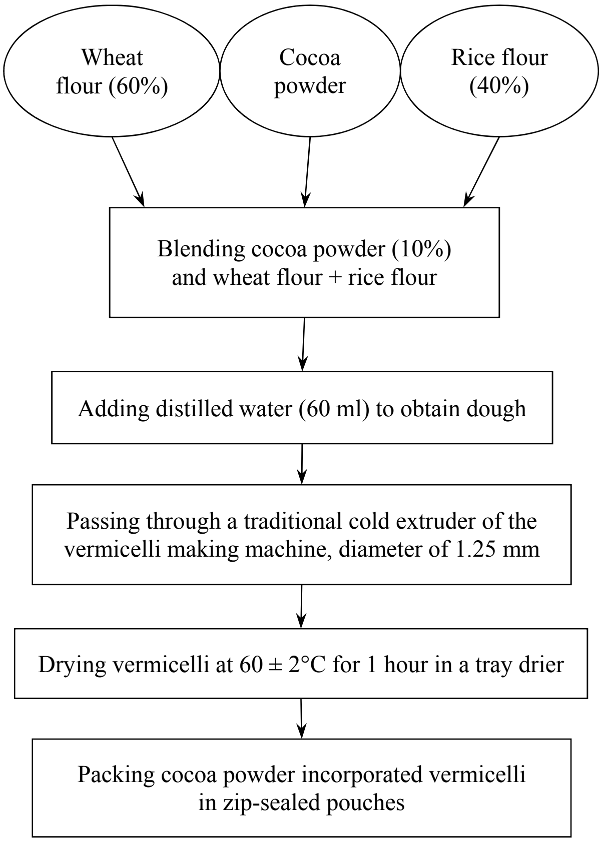


Fig. 1. Process flow chart for the production of cocoa powder vermicelli.

RESULTS AND DISCUSSION

Nutritional profiling of vermicelli. The ap proximate composition of vermicelli with cocoa powder incorporated into the blend is given in Table 1. The mean moisture content of vermicelli incorporated with cocoa powder decreased from 8.78 (100% WRF and 0% CP) to 6.89 (80% WRF and 20% CP) per cent. A low moisture content is a favourable factor in increasing the shelf stability of the product. The protein content increased significantly with the increase in cocoa solids which may be ascribed to the addition of various amounts of cocoa powder to the experimental treatments of vermicelli. The ash content increased significantly ($p < 0.05$), which could be attributed to the high mineral content in the cocoa powder, i.e. 5.7 g/100g [5]. A significant increase in the fat content ranging from 1.34 to 4.06 (80% WRF and 20% CP) per cent was observed. These values are which is less than the values of the fermented cocoa beans, which vary from 10.115 to 12.015% as reported by Ajala and Ojewande [13]. A low fat content in the diet helps in reducing coronary heart diseases and improves health as stated by Osakebe et al. [14]. The difference method was used to calculate the carbohydrate content of the samples. The carbohydrate content decreased, and a significant difference ($p < 0.05$) was observed in and above 10% cocoa powder incorporation. The energy value ranged from 365 (control) to 385 Kcal/100 g (20% incorporation). There was a significant increase ($p < 0.05$) in the calorific value with the increase in the percentage of cocoa powder. The increase in the calorific value of the developed cocoa-based vermicelli could be attributed to the high content of fat and protein in the cocoa powder [5].

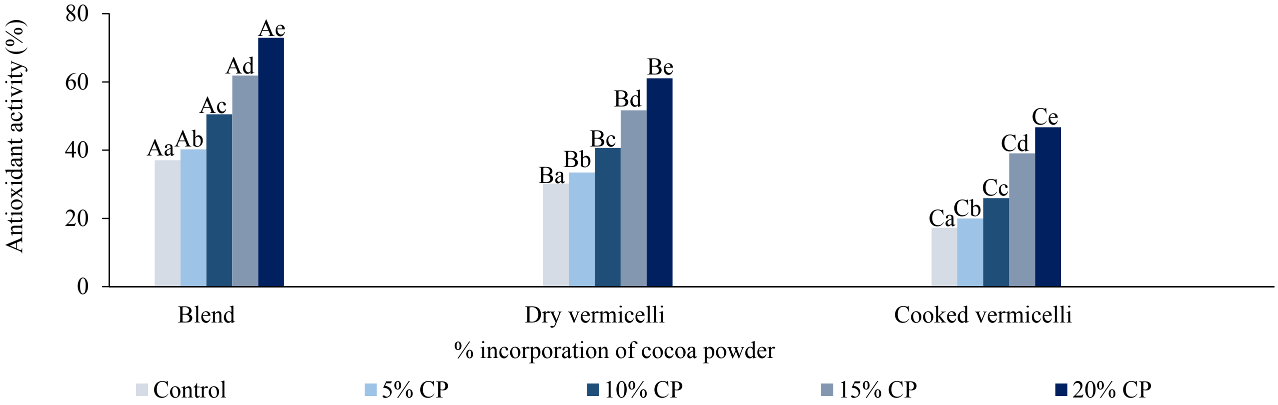
Antioxidant activity. The antioxidant activity was observed in the blend, dry as well as cooked vermicelli, and a significant difference was observed with the increase in the cocoa powder incorporation (Fig. 2). The antioxidant activity ranged from 37 (100% WRF and 0% CP) to 72.96 (80% WRF and 20% CP) per cent in blends, from 30.22 (100% WRF and 0% CP) to 61.07 (80% WRF and 20% CP) in dry vermicelli, and from 17.28 (100 % WRF and 0% CP) to 46.73 (80% WRF and 20% CP) in cooked vermicelli. The antioxidant percentage has increased in all cases. The observed effect of drying and cooking on the antioxidant level is shown in Fig. 2. Similar results were reported by Ajibola et al. [3], in their study of whole-wheat biscuits with cocoa powder and *Moringa oleifera* leaves incorporation. They reported a substantial increase in the antioxidant activity with the incorporation of 5% cocoa powder.

Cooking and functional properties of cocoa vermicelli. The cocoa powder vermicelli was analysed for its cooking properties**.** Table 2 shows the cooking properties of cocoa incorporated vermicelli. Bulk density is a good physical attribute for determining the mixing quality of particulate matter and helps in indicating the relative amount of packaging material [4]. The moisture content of a product affects the bulk density of the sample. A similar result has been reported by Ajala and Ojewande [13] in their study on drying of fermented cocoa beans. They stated that bulk density of cocoa powder increased with the decrease in a moisture content. The cooked weight decreased significantly ($p < 0.05$) from 12.02 (control) to 9.93 (5% incorporation) with an increase in the cocoa powder incorporation. This could be due to the decrease in a starch content owing to cocoa powder incorporation, resulting in the reduction of imbibed water.

Table 1. Approximabe composition of blends

Sample Code	Moisture content, %	Ash, %	Protein, %	Fat, %	Carbohydrate,%	Energy value, (Kcal/100g)
Control	8.78 ± 0.14^{a}	0.94 ± 0.12^{a}	9.13 ± 0.05^{a}	1.34 ± 0.01^{a}	79.81 ± 0.17^{a}	365 ± 0.10^{a}
CP_1	8.13 ± 0.06^{b}	1.09 ± 0.19^{b}	9.58 ± 0.06^{b}	1.83 ± 0.02^{b}	79.38 ± 0.10^{a}	371 ± 0.17^{b}
CP_2	7.97 ± 0.18^{c}	1.17 ± 0.09^{c}	9.86 ± 0.11^{c}	2.40 ± 0.04^{c}	78.63 ± 0.09^{b}	375 ± 0.14^{c}
CP_3	7.32 ± 0.17^{d}	1.51 ± 0.06^{d}	10.52 ± 0.10^{d}	3.14 ± 0.08^{d}	77.43 ± 0.16^{c}	380 ± 0.21^{d}
CP_4	6.89 ± 0.13^{e}	1.89 ± 0.15^{e}	11.21 ± 0.03^{e}	4.06 ± 0.09^{e}	75.92 ± 0.08^{d}	385 ± 0.13^{e}

Note. CP_1: 5% cocoa incorporation, CP_2: 10% cocoa incorporation, CP_3: 15% cocoa incorporation, CP_4: 20% cocoa incorporation.
The values are represented in Mean ± Standard deviation derived for triplicate experiments (n = 3). The values denoted with different superscripts differ significantly at $p < 0.05$ in a column.



Note. The values are represented in Mean ± Standard deviation derived for triplicate experiments (n = 3). The values denoted with the capital letters differ significantly at $p < 0.05$ in different treatments. The values denoted with small letters differ significantly at $p < 0.05$ in the percentage of incorporated cocoa powder.

Fig. 2. Graphical representation of antioxidant properties of cocoa incorporated vermicelli.

Table 2. Cooking and functional properties of cocoa vermicelli

Sample Code	Cooked weight (g)	Cooking time (min)	Gruel solid loss (g/100g)	Bulk density (g/cm^{3})	WAC, %
Control	12.02 ± 0.03^{a}	6.20 ± 0.05^{a}	0.18 ± 0.01^{a}	0.789 ± 0.01^{a}	121 ± 4.83^{a}
CP_1	11.81 ± 0.02^{b}	6.80 ± 0.15^{b}	0.22 ± 0.01^{a}	0.769 ± 0.01^{a}	136 ± 3.12^{b}
CP_2	11.56 ± 0.05^{c}	7.21 ± 0.19^{c}	0.47 ± 0.04^{b}	0.714 ± 0.03^{b}	146 ± 3.60^{c}
CP_3	10.90 ± 0.10^{d}	8.03 ± 0.20^{d}	0.62 ± 0.08^{c}	0.681 ± 0.04^{c}	176 ± 3.12^{d}
CP_4	09.93 ± 0.06^{e}	9.17 ± 0.16^{e}	0.80 ± 0.04^{d}	0.642 ± 0.02^{d}	181 ± 4.57^{e}

Note. CP_1 5% cocoa incorporation, CP_2 – 10% cocoa incorporation, CP_3 – 15% cocoa incorporation, CP_4 – 20% cocoa incorporation.
The values are represented in Mean ± Standard deviation derived for triplicate experiments (n = 3). The values denoted with different superscripts differ significantly at $p < 0.05$ in a column.

Table 3. Sensory properties of cocoa vermicelli

Sample	Color & Appearance	Taste	Aroma	Texture	Overall Acceptability
Control	7.33 ± 0.41^{a}	7.13 ± 0.22^{a}	6.75 ± 0.04^{a}	6.98 ± 0.83^{a}	7.04 ± 0.03^{a}
CP_1	7.00 ± 0.41^{c}	7.00 ± 0.20^{c}	6.83 ± 0.30^{b}	6.88 ± 0.99^{a}	6.92 ± 0.07^{c}
CP_2	7.44 ± 0.53^{b}	7.44 ± 0.53^{b}	7.50 ± 0.53^{b}	7.50 ± 0.76^{a}	7.47 ± 0.01^{b}
CP_3	6.89 ± 0.76^{d}	7.00 ± 0.62^{c}	6.65 ± 0.41^{c}	6.18 ± 0.06^{b}	6.68 ± 0.04^{d}
CP_4	6.33 ± 0.32^{e}	6.19 ± 0.62^{d}	6.50 ± 0.51^{c}	6.00 ± 0.19^{c}	6.25 ± 0.06^{e}

Note. CP_1 is 5% cocoa incorporation, CP_2 – 10% cocoa incorporation, CP_3 – 15% cocoa incorporation, CP_4 – 20% cocoa incorporation.
The values are represented in Mean ± Standard deviation derived for triplicate experiments (n = 3). The values denoted with different superscripts differ significantly at $p < 0.05$ in a column.

The increased water absorption capacity is also an indicator for the increased cooked weight of the formed samples [15]. It is evident from Table 2 that the cooking time increased significantly at $p < 0.05$, with the increase in cocoa powder levels from 6.80 (5% incorporation) to 9.17 min (20% incorporation) while the control vermicelli took 6.20 min to cook. This could be due to the high starch content and a lower gelatinisation thus achieved. It was noted that gruel solid loss of the cooked vermicelli showed a significant increase in all samples with cocoa incorporation (viz. CP_1, CP_3, CP_4, and CP_5). The result reported in the present experiments was in agreement with those observed in Ronge et al. [16]. The functional property, water absorption capacity (WAC), is an indicator of the association of water with the product at instances where water is a factor subjected to limitations. It was observed that WAC increased with an increase in cocoa powder proportion. This could be attributed to such properties of a cocoa powder as hygroscopicity, low water activity, and high dietary fibre content as stated by Victor et al. [17].

Sensory properties. The scores of sensory evaluation were attained for various sensory characteristics, such as colour and appearance, taste, aroma, texture, and overall acceptability. All the values obtained are shown in Table 3, for the sensory attributes of the different types of cocoa vermicelli were well accepted by the sensory panellists. The 10% incorporation of cocoa powder was acceptable in all sensory parameters except texture. The sensory score for colour, appearance, and the overall acceptability of the product varied significantly among different samples at $p < 0.05$. The overall acceptability of sample 2 (CP_2), which is made of 10% cocoa powder incorporation, is higher compared to the others.

CONCLUSION

About five different treatments with different concentrations of cocoa powder (0, 5, 10, 15, and 20%) were made including control (whole wheat flour). With the increase in cocoa powder levels, the fat, protein, and ash content of vermicelli also increased significantly ($p < 0.05$). It has been observed that there was a decrease in the moisture content, which is a good indicator for shelf-life. Furthermore, the gruel solid loss and water absorption capacity increase significantly ($p < 0.06$) as the cocoa powder incorporation increases. The high antioxidant property of cocoa powder increases both the nutritional value and the antioxidant activity of vermicelli. The cocoa powder incorporation up to 10% was found to be acceptable. The optimized product with 10% cocoa powder incorporation had 0.714 g/cm^3 bulk density, 11.56 g cooked weight, 7.21 min cooking time, 0.47 g/100 g gruel solid loss, and 146% water absorption capacity. The optimized cocoa-based vermicelli was high in calories with 375 Kcal/100g of the product.

CONFLICT OF INTEREST

The authors declare no conflict of interests.

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