International Journal of Biochemistry Research & Review

17(4): 1-7, 2017; Article no.IJBCRR.33992
ISSN: 2231-086X, NLM ID: 101654445

Sensory Properties and Microbial Characteristics of Cookies Prepared from Refined Wheat Flour Supplemented with Sweet Potato Flour and Whey Protein Concentrate

Blessy Sagar Seelam[1*], John David[1], Neha Singh[1] and Sonia Morya[1]

[1]Warner College of Dairy Technology, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad 21107, India.

Authors' contributions

This work was carried out in collaboration between all authors. Authors BSS and JD designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author NS managed the analyses of the study. Author SM managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJBCRR/2017/33992
Editor(s):
(1) Fatih Oz, Food Engineering Department, Agriculture Faculty, Ataturk University, Turkey.
Reviewers:
(1) Shivani Pathania, Teagasc Food Research Centre, Republic of Ireland.
(2) Uttara Singh, Panjab University, India.
(3) Sherif Ramzy Mohamed, National Research Centre, Egypt.
Complete Peer review History: http://www.sciencedomain.org/review-history/19911

Original Research Article

Received 8th May 2017
Accepted 28th June 2017
Published 7th July 2017

ABSTRACT

A study was conducted for sensory analysis and microbial assay for the cookies supplemented with refined wheat flour, sweet potato flour and whey proteins concentrate (WPC-80). The cookies made were nutritious products for all peoples. The product on the whole composed of sweet potato flour, whey protein concentrate (WPC-80), refined wheat flour and other ingredients such as butter and sugar. The product was made with different formulations. Sensory evaluation was done for acceptability of the product and microbial study was conducted for the developed cookies. Results from sensory analysis revealed that all treatment combinations are in acceptable level. Among all, T_3 HT1 (20% SPF and 20% WPC) scored best in overall acceptability. The SPC ranges from 1.400±0.548 to 4.400±0.548 from 0^{th} to 30^{th} days, Yeast and mould was NIL in 0^{th} and 15^{th} day on 30^{th} it was recorded. Coli forms count is NIL in 0^{th} day and it was recorded in 15^{th} and 30^{th} days for different treatment combination.

**Corresponding author: E-mail: blessysagar@gmail.com;*

Keywords: Sweet potato flour; whey protein concentrate; cookies sensory evaluation; microbial assay.

1. INTRODUCTION

The sweet potato *Ipomoea batatas* (L.) belongs to the Convolvulaceae. Sweet potato is among the world's most important and under-exploited crop [1]. Sweet-potato (*Ipomoea batatas* L) is the seventh most important food crop in the world. It is grown in many tropical and subtropical regions. Among the world's major food crops, sweet-potato produces the highest amount of edible energy/ha/day [2]. Sweet-potato flour can serve as a source of energy and nutrients (carbohydrates, beta-carotene (pro-vitamin A), minerals (Ca, P, Fe, and K), and can add natural sweetness, color, flavor, and dietary fiber to processed food products. Because of the distinct properties, the use of sweet-potato flour in the preparation of bread is restricted; Biscuits are baked dry products, usually with a golden brown crust and crispy texture [3].

Whey was previously considered as waste because of its potential for spoilage. Now days however it is no longer considered as a waste product but treasure of nutritionally rich whey proteins. WPC has many health benefits and clinical importance. WPC is useful in the treatment of various diseases and health problems such as cancer and high cholesterol [4]. It is effective in trauma, burn and renal failure [5,6]. It has the ability to act as antibacterial and antiviral agent [7]. Whey proteins are easily and readily digested and therefore useful in post operative care of patients. Its use is beneficial in diabetes, cardiac ailment, liver problem, arthritis, gout and antihypertensive. It is antitumor agent and giving antioxidant effect [8,9]. WPC has immune-enhancing property due to which it can be used in treating HIV patients. Whey protein also acts as a sport, food as whey proteins helps in speedy repairing of injured and torn muscle during practice and performance [10,11]. Whey proteins provide excellent nutritional values in nutrition, foods formulated for infant, kids, adults and old aged people as growth tonic for body health maintenance.

Bakery industry in India is considered as one of the major food processing industry with an annual demand of over 2758 MT [11]. (Ministry of Food Processing Industries, 2013). India is known to be the second largest manufacturer of biscuits, first being USA. Bakery products are the most popular food consumed by all age groups and are gaining popularity as processed foods because of their availability, ready to eat convenience, and comparatively good shelf life.

As discussed above, it is clear that sweet potato flour is rich in dietary fiber, functional fiber. Whey protein concentrate is rich in available protein content, high calcium and minerals, it can be considered as fortification for plain cookies.

2. MATERIALS AND METHODS

Sweet potatoes were procured locally from the field after harvesting. Roots were washed, trimmed and cured to make them free from soil and other foreign materials, rotting, insect damage and washed with common salt and made into slices, dried by using a tray drier at 60℃ for 6 h and then Grinding, Sieving on 70 mesh [2]. The prepared Sweet potato flour Packed in HDPE and stored for 6 months or more in sealed containers.

WPC were procured from Mahan proteins ltd., Delhi, India. Refined wheat flour, sugar, shortening (Amul Butter) were procured from local market of Allahabad (India) and kept at room temperature for further use. All chemicals used were of analytical grade.

2.1 Preparation Dough for Cookies

The dough was made in a laboratory mixer. Fat and sugar was creamed in a mixer with a flat beater for 2 min at slow speed. Sodium chloride was added to the resulting cream, and mixed for 5 min at high speed to obtain a homogeneous mixture. Finally, flour containing various proportions of sweet potato flour, and whey protein concentrate (WPC-80), which had been sieved twice with baking powder was added, and mixed for 3 min at medium speed. The dough preparation, sheeting and moulding followed by different heat treatments like baking at 180℃ for 15 mins, microwave heating at 180℃ for 10 mins and frying at 180℃ 8 mins. Combination treatment with different heat treatments is given in the following Table 2.1.

2.2 Sensory Evaluation

The evaluation was done by 5 trained and semi trained panelists at Warner College of Dairy Technology, SHUATS. Judgments for developed cookies were made through rating products on a5 point Hedonic scale [12]. With corresponding descriptive terms ranging from 5 'like extremely'

Table 2.1. Treatment combination of different cookies

Heat treatments	Treatment combinations	Refined wheat flour	Sweet potato flour	Whey protein concentrate (WPC-80)
Baking at 180^0C for 15 mins.	T_0 HT_1	100	-	-
	T_1 HT_1	60	40	-
	T_2 HT_1	60	30	10
	T_3 HT_1	60	20	20
	T_4 HT_1	60	10	30
	T_5 HT_1	60	-	40
Microwave heating at 180^0C for 10 mins.	T_0 HT_2	100	-	-
	T_1 HT_2	60	40	-
	T_2 HT_2	60	30	10
	T_3HT_2	60	20	20
	T_4 HT_2	60	10	30
	T_5HT_2	60	-	40
Frying at 180^0C 8 mins.	T_0 HT_3	100	-	-
	T_1HT_3	60	40	-
	T_2HT_3	60	30	10
	T_3 HT_3	60	20	20
	T_4HT_3	60	10	30
	T_5 HT_3	60	-	40

to 1 ‘dislike extremely’ having different quality attributes such as colour and appearance, body and texture, flavor and taste, mouth feel and over-all acceptability.

2.3 Microbial Analysis

Standard plate count, Yeast and mould and Coli form were determined by using serial dilution pour plate method. The number of colonies appeared on dilution plates were counted, averaged and reported as cells per gram (cfu/gm) of the sample.

2.4 Statistical Analysis

To determine the statistical significance of sensory and microbial evaluation of cookies were analyzed using minitab18 software by ANOVA followed by Tukey's test (one-way) at a 5% significance level. All values are expressed as mean and standard deviation of five parallel measurements.

3. RESULTS AND DISCUSSION

3.1 Sensory Properties of Different Types of Cookies

Organoleptic evaluation offers the opportunity to obtain a complete analysis of various properties of food as perceived by human senses. Sensory evaluation is an important and best method for evaluating the organoleptic properties of various products which provide quality measure and production control. To select the sensory attractive cookies prepared by different combinations of sweet potato and whey protein concentrate (WPC-80), were subjected to sensory evaluation using 5 point hedonic scale. Colour and appearance , body and texture ,flavor and taste, mouth feel and over all acceptability were the parameters studied for selecting the better product among the different treatment combinations. Oraganoleptic evaluation of developed cookies was carried out by a panel of 5 semi trained panel members and best product was selected based on the results from the score card. The results of various quality attributes are present in the Tables 3.1a, 3.1b and 3.1c and Fig. 3.1.

The results of sensory evaluation of cookies indicated that among the different treatment combinations, T_1HT_3 (4.900± 0.224) was better acceptable in terms of colour and appearance. T_0 HT_3 (4.600±0.548) for flavour & taste, T_3 HT_1 (4.700±0.274) for body and texture, T_3 HT_1 (4.500±0.500) for mouth feel and T_3 HT_1 (4.800±0.274) for over- all acceptability.

The sensory evaluations for three heat treatments were good in taste. The body and texture, consistency of fried cookies were reported to be too soft because of porous structure developed during frying process; heat is transferred from hot oil to the product surface by convection and from the surface to the centre

Table 3.1a. Sensory properties of baked cookies

Treatments combinations	Colour and appearance of cookies	Flavour and taste	Body and texture of cookies	Mouth feel	Over all acceptability
T_0HT_1	3.600±0.894^{ab}	3.400±0.548^{a,b}	3.000±0.000^{c}	3.600±0.548^{a,b}	3.200±0.447^{c}
T_1HT_1	4.600±0.548^{a}	4.200±0.447^{a}	4.400±0.548^{a}	4.400±0.548^{a,b}	4.600±0.548^{a,b}
T_2HT_1	3.400±0.548^{b}	3.600±0.548^{a,b}	3.400±0.548^{b,c}	3.400±0.548^{b}	3.600±0.548^{b,c}
T_3HT_1	4.600±0.224^{a}	4.200±0.447^{a}	4.700±0.274^{a}	4.500±0.500a	4.800±0.274^{a}
T_4HT_1	3.200±0.447^{b}	2.700±0.447^{b}	2.900±0.742^{c}	3.400±0.548^{b}	3.300±0.671^{c}
T_5HT_1	4.200±0.274^{ab}	4.100±0.742^{a}	4.100±0.548^{a,b}	4.100±0.548^{a,b}	4.100±0.548^{a,b,c}

Values are means ± standard deviation from five parallel observations
Same letters within the same column do not differ significantly (p < 0.05) according to Tukey's test

Table 3.1b. Sensory properties of microwaved cookies

Treatments combinations	Colour and appearance of cookies	Flavour and taste	Body and texture of cookies	Mouth feel	Over all acceptability
T_0HT_2	3.600±0.548^{c,d}	3.200±0.447b	3.600±0.548^{a}	4.000±0.000a,b	4.000±0.000^{a,b}
T_1HT_2	4.500±0.354^{a}	3.300±0.274b	4.000±0.612^{a}	4.000±0.612a,b	4.400±0.224^{a}
T_2HT_2	4.200±0.274^{a,b,c}	3.600±0.548a,b	3.900±0.224^{a}	4.100±0.224a,b	4.200±0.274^{a,b}
T_3HT_2	4.400±0.548^{a,b}	4.400±0.548a	4.100±0.548^{a}	4.400±0.548a	4.300±0.447^{a}
T_4HT_2	3.700±0.274^{b,c,d}	3.700±0.447a,b	3.500±0.500^{a}	3.600±0.418a,b	3.700±0.274^{b}
T_5HT_2	3.000±0.000^{d}	3.100±0.224b	2.400±0.418^{b}	3.400±0.418b	2.700±0.274^{c}

Values are means±standard deviation from five parallel observations
Same letters within the same column do not differ significantly (p < 0.05) according to Tukey's test

Table 3.1c. Sensory properties of fried cookies

Treatments combinations	Colour and appearance of cookies	Flavour and taste	Body and texture of cookies	Mouth feel	Over all acceptability
T_0HT_3	4.400±0.548^{a,b}	4.600±0.548^{a}	4.200±0.837^{a,b}	4.400±0.548^{a}	4.600±0.548^{a}
T_1HT_3	4.900±0.224^{a}	3.200±0.274^{b}	4.400±0.418^{a,b}	3.600±0.418^{a,b}	4.400±0.418^{a}
T_2HT_3	3.900±0.742^{a,b,c}	3.900±0.742^{a,b}	4.600±0.548^{a}	4.200±0.447^{a}	4.200±0.837^{a}
T_3HT_3	3.300±0.274^{c,d}	3.700±0.447^{a,b}	4.000±0.000^{a,b}	3.600±0.418 ^{a,b}	3.700±0.274^{a,b}
T_4HT_3	3.800±0.837^{b,c,d}	3.600±0.894^{a,b}	3.300±0.975^{b,c}	3.600±0.894^{a,b}	3.700±0.837^{a,b}
T_5HT_3	2.800±0.274^{d}	2.800±0.447^{b}	2.400±0.418^{c}	3.000±0.000^{b}	2.900±0.224^{b}

Values are means±standard deviation from five parallel observations
Same letters within the same column do not differ significantly (p < 0.05) according to Tukey's test

by conduction. The liquid water moves from inside of the fries to the evaporation zone leaving the product from the surface as vapour. Some of this vapour though, may remain trapped within the pores due to restrictive intercellular diffusion. The vapour in this confined space will expand and become superheated, distorting the pore walls and contributing to total porosity [13,14]. As the sweet potato flour concentration increased, the softness is decreased. It was reported in baking and microwave heat treatments were almost same but crust is for in baked cookies. One of the most important changes is the product evolving from semi-viscous dough to a solid alveolar structure at the end of baking. Air bubbles, introduced during the mixing of ingredients expand within the product during baking and contribute also to the volume expansion although to a lesser extent. Finally, upon baking the water evaporation/condensation within the product structure results in a significant moisture loss qualified as moderate drying.

Another important reaction influencing the quality of baked product is the appropriate brown color development on the surface by sugar caramelization, Maillard reactions, starch dextrination and/roasting of protein network [15]. Where as in micro wave heating process avoids the problem of crust formation and surface

browning. In contrast to conventional baking microwave heating inactivates this enzyme fast enough (due to a fast and uniform temperature rise in the whole product) to prevent the starch from extensive breakdown, and develops sufficient CO2 and steam to produce a highly porous [16].

Crispness is more in 40% sweet potato flour incorporated cookies (T_3 HT_1, T_3 HT_2) as per the sensory evaluation. The overall acceptability of the cookies was almost similar in baking and microwave heat treatments.

3.2 Microbiological Assay of Different Types of Cookies

The obtained results for standard plate count (SPC), Yeast and mould and Coli forms in developed cookies are presented in Tables 3.2a, 3.2b and 3.2c. On 0^{th} day the SPC for baked cookies was more in T_5 HT_1 (3.600±0.894) which was recorded in 40% whey protein concentrate (WPC-80), incorporated cookies and least in T_2 HT_1 as the days increased standard plate count (SPC) gradually increased. Yeast and mould count was recorded nil in 0^{th} and 15^{th} where as on 30^{th} T_5 HT_1 was recorded as 0.200±0.00 where as in Coli forms was highest on 30^{th} day in T_1 HT_1 (2.800±0.447) and the least was recorded on 0^{th} day (Nil).

In microwave treated cookies SPC is high in T_1HT_2 (2.200±0.837) and T_3HT_2 (2.200±0.837) and least in T_2 HT_2 (1.400±0.548) in on 0^{th} day. Yeast and mould count was recorded nil in 0^{th} and 15^{th} where as on 30^{th} T_5 HT_5 was recorded as 0.25±0.434. Coli form is nil on 0^{th} day and 15^{th} day it is recorded in T_5HT_2 (1.520±0.449). On 30^{th} day coli form was recorded more which is highest in T_3HT_2 (2.360±0.590) and least in T_4 HT_2 (1.360±0.498).

In fried cookies SPC, Yeast and mould and Coli form is recorded high as compared to the baked and microwave treated cookies. SPC ranges from 1.600±0.548 (T_2HT_3) to 4.400±0.548 (T_5 HT_3) on 0^{th} day. SPC increased on 15 to 30^{th} day. Yeast and mould recorded nil on 0^{th} and 15^{th} day where as on 30^{th} it is recorded in T_5 HT_3 (0.1200±0.548) coli form is more on 30^{th} day as compared to 0^{th} and 15^{th} day. It was observed that the all the treatment combinations values are still within acceptable limit.

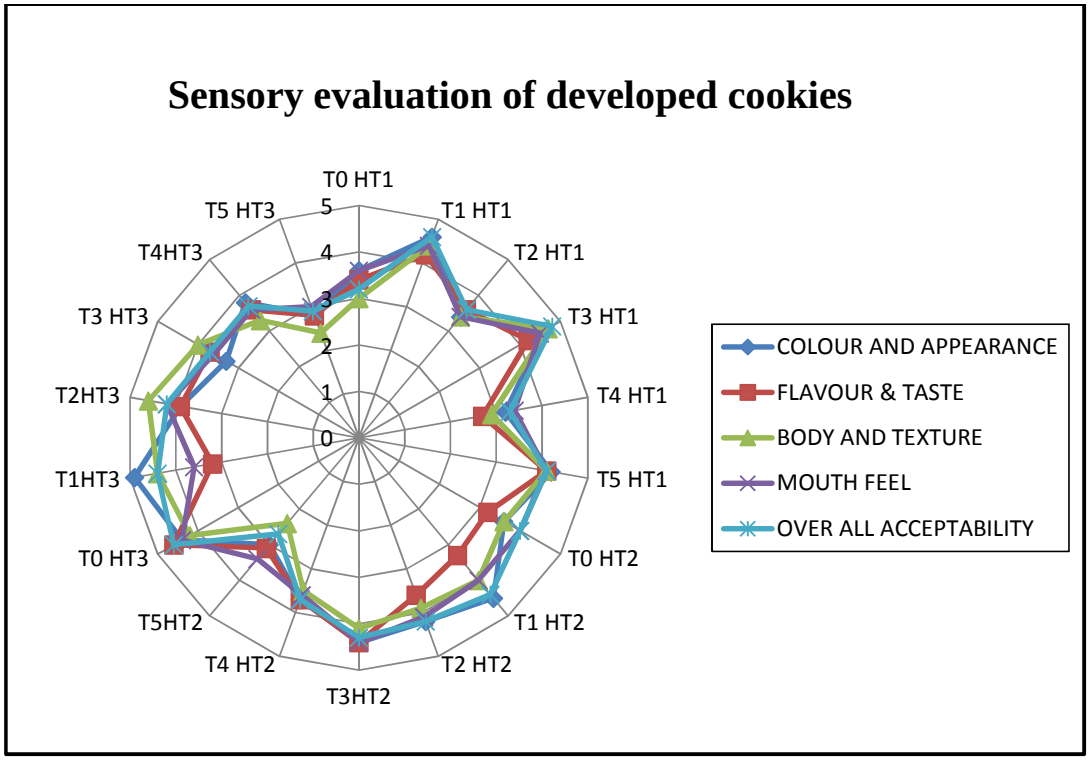

Fig. 3.1. Sensory evaluation of developed cookies

Table 3.2a. Microbial assay of baked cookies

Treatmet combinations	SPC(10^3) cfu/gm			Yeast and mould (cfu/gm)			Coli forms(10^3) cfu/gm		
	0^{th} day	15^{th} day	30^{th} day	0^{th} day	15^{th} day	30^{th} day	0^{th} day	15^{th} day	30^{th} day
$T_0 HT_1$	1.800±0.844^{b}	2.600±0.894^{b,c}	3.200±0.837^{b}	Nil	Nil	Nil	Nil	Nil	1.400±0.548^{b}
$T_1 HT_1$	2.400±0.548^{a,b}	3.200±0.447^{a,b}	4.600±0.548^{a}	Nil	Nil	Nil	Nil	Nil	2.800±0.447^{a}
$T_2 HT_1$	1.400±0.548^{b}	1.800±0.447^{c}	2.200±0.837^{b}	Nil	Nil	Nil	Nil	Nil	1.800±0.837^{a,b}
$T_3 HT_1$	1.800±0.837^{b}	2.600±0.548^{b,c}	2.800±0.447^{b}	Nil	Nil	Nil	Nil	Nil	1.320±0.460^{b}
$T_4 HT_1$	2.200±0.447^{b}	2.600±0.548^{b,c}	3.200±0.447^{b}	Nil	Nil	Nil	Nil	Nil	1.800±0.447^{a,b}
$T_5 HT_1$	3.600±0.894^{a}	4.200±0.447^{a}	4.600±0.548^{a}	Nil	Nil	0.200±0.00^{a}	Nil	1.480±0.449^{a}	1.920±0.1789^{a,b}

Values are means±standard deviation from five parallel observations; Same letters within the same column do not differ significantly (p < 0.05) according to Tukey's test

Table 3.2b. Microbial assay of microwaved cookies

Treatment combinations	SPC(10^3) cfu/gm			Yeast and mould (cfu/gm)			Coli forms(10^3) cfu/gm		
	0^{th} day	15^{th} day	30^{th} day	0^{th} day	15^{th} day	30^{th} day	0^{th} day	15^{th} day	30^{th} day
$T_0 HT_2$	2.000±0.707^{b}	3.000±0.707^{b}	4.000±0.7071^{a,b}	Nil	Nil	Nil	Nil	Nil	1.480±0.502^{a}
$T_1 HT_2$	2.200±0.837^{b}	2.800±0.447^{b}	3.800±0.8367^{a,b}	Nil	Nil	Nil	Nil	Nil	1.880±0.522^{a}
$T_2 HT_2$	1.400±0.548^{b}	1.800±0.447^{c}	2.200±0.4472^{c}	Nil	Nil	Nil	Nil	Nil	1.760±0.434^{a}
T_3HT_2	2.200±0.837^{b}	3.200±0.447^{b}	3.400±0.5477^{b,c}	Nil	Nil	Nil	Nil	Nil	2.360±0.590^{a}
$T_4 HT_2$	2.800±0.447^{a,b}	3.00±0.0000^{b}	3.800±1.0954^{a,b}	Nil	Nil	Nil	Nil	Nil	1.360±0.498^{a}
T_5HT_2	4.200±0.8370^{a}	4.600±0.548^{a}	5.200±0.4472^{a}	Nil	Nil	0.250±0.434^{a}	Nil	1.520±0.449^{a}	1.560±0.518^{a}

Values are means±standard deviation from five parallel observations; Same letters within the same column do not differ significantly (p < 0.05) according to Tukey's test

Table 3.2c. Microbial assay of fried cookies

Treatment combinations	SPC(103) cfu/gm			Yeast and mould (cfu/gm)			Coli forms(10^3) cfu/gm		
	0^{th} day	15^{th} day	30^{th} day	0^{th} day	15^{th} day	30^{th} day	0^{th} day	15^{th} day	30^{th} day
$T_0 HT_3$	2.200±0.837^{b,c}	3.200±0.447^{b,c}	4.600±0.548a,b	Nil	Nil	Nil	Nil	Nil	1.520±0.502^{b}
T_1HT_3	2.000±0.707^{b,c}	2.600±0.548^{c,d}	3.400±0.548b,c	Nil	Nil	Nil	Nil	Nil	2.200±0.447^{a,b}
T_2HT_3	1.600±0.548^{c}	2.200±0.447^{d}	2.600±0.548c	Nil	Nil	Nil	Nil	Nil	1.520±0.502^{b}
$T_3 HT_3$	2.400±0.548^{b,c}	3.800±0.447^{b}	4.200±0.447a,b	Nil	Nil	Nil	Nil	Nil	2.040±0.0894^{a,b}
T_4HT_3	3.200±1.095^{a,b}	3.600±0.548^{b}	4.200±0.837a,b	Nil	Nil	Nil	Nil	0.80± 0.748^{b}	1.720±0.832^{a,b}
$T_5 HT_3$	4.400±0.548^{a}	4.800±0.447^{a}	5.400±0.894a	Nil	Nil	0.12±0.548^{a}	Nil	1.96±0.080^{a}	2.680±0.460^{a}

Values are means±standard deviation from five parallel observations; Same letters within the same column do not differ significantly (p < 0.05) according to Tukey's test

4. CONCLUSION

From the present study, it could concluded that the 20% SPF and 20% WPC (T_3 HT_1 and T_3 HT2)-supplemented cookie samples were nutritionally rich as well as more sensory acceptable product with regardless of both baking and microwave heat treatments. Evaluation results revealed that 40% SPF (T_1 HT_3) are also good in taste. The standard plate Count, yeast and mould count and coli forms of cookie samples were found within the acceptable limits. Thus, the present our study concludes that the supplementation level of 20% SPF and 20% WPC (T_3 HT_1) results are acceptable in the sensory, textural and nutritional characteristics.

ACKNOWLEDGEMENT

This paper is part of Ph.D research which has been conducted at SHAUTS, Authors are thankful for the university for providing necessary facilites to complete this research work.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/19911