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Research Article

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Formulation And Characterization Of Omega 3 Enriched Pasta`

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ABSTRACT

Objectives: This study was performed to find out the effect of omega 3 on the quality of chia seeds (CS) , flax seeds (FS) and walnuts (WN) powder were incorporated in pasta. Material and Methods: Three different types of omega 3 enriched foods such as chia seeds, flax seeds and walnuts each at 0.5,1,1.5 and 2 percentage were added and analyzed their physiochemical, Nutritive value, Organoleptic parameters of omega 3 enrich chia seeds (CS),Flax Seed (FS) and Walnut(WN) incorporated pasta Result: The Colour, cooking time, water absorption and volume expansion of (CS) and (FS) increased ($P<0.05$) with the percentage is increased and except the swelling index for (WN) pasta .Most of the nutritive value such as energy, protein, fat, fiber, Zinc, calcium, phosphorus. vitamin A, Thiamin, Riboflavin, Niacin, vitamin C, Iron, Folic acid, Sodium are increased with increased percentage of omega 3 (CS),(FS) and (WN) enrich pasta .The omega 3 (ALA) were increased with increased percentage . The taste, appearance, flavor , colour and The overall acceptability were Slightly decreased with increased percentage ($P>0.05$) Conclusion: Hence, omega 3 enrich pasta with majority desirable characteristic from (CS),(FS) and (WN) powder, it is recommended that the 2 percentage of incorporated (CS),(FS) and (WN) in the formulation of omega 3 pasta

Keywords: Chia Seeds, Flax seeds, walnut, Omega -3 and Pasta

Introduction

The Pasta processing is a big advantage for product innovation in different variation forms (Duda et al., 2019 and Kowalczewski et al.,2019).[1,2] The food technologists are curious in utilizing flaxseed *(Linum usitatissimum*) in food manufacturing because of its health effects(Giada 2010, Manthri and Carraro et al.,2012).[3,4,5] Cereal products can be made by fortification with different flaxseed forms (Kaur et al.,2018).[6]The structure can affect the release of bioactive components of flaxseed at the target site of the digestive system. Flaxseeds must be milled or ground to approach their full nutritional value (Kuijsten A et al.,2005). [7] Flaxseed is a rich source of alpha linolenic acid (ALA) which represents more than half of total fat in flaxseed (Imran et al.,2015).[8] found that raw flaxseed meal was characterized by the highest oxidative stability. It shows that extruded flaxseed meal can be used for production of health-enhancing products due to its long-term stability. Mexican Chia (*Salvia hispanica L*) is annual grass plant in the lamiaceae family that was named in Central America around 2600 B.C. Increasing amount of Study(Reyes-Caudillo et al., 2008).[9] have shown that chia seeds (Fruits that don't break down) are full of polyunsaturated fatty acids, antioxidants, vitamins, and minerals. Beyond 30% oil, the seeds are one of the best natural sources of the important fatty acid α-linolenic[18;3(n-3)] (Sandoval-oliveros 2013).[10] chia seeds have a high-quality protein content (about19-27%) with a decent balance of key amino acids, Particularly methionine and cysteine. They are rich in flavonols (myricetin, quercetin, and kaempferol) and Phenolic acid(Chlorogenic and caffeic acids),Which are natural antioxidants (Amato M et al.,).[11] Many countries have long regarded walnuts (*Juglans regia L*), the most common tree nut in the world, as a nutrient-dense Diet)(Regueiro et al 2014 and Shojaei A et al 2023).[12,13]These nuts are known for a variety of different bioactive substance, including polyphenols(Sanchez-Gonzalez et al., 2017).[14]as well as their lipid profile, Particularly the amount of essential fatty acids(Shahidi-Noghabi et al).[15]Among the most common types of phytochemicals are phenolic compounds, which are further subdi-

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vided into tannins, coumarins, stilbenes, Flavonids and Phenolic compounds may be beneficial to human health because of their anti-aging, anti-carcinogenic, anti-bacterial, anti-fungal, anti-inflammatory and neuroprotective qualities(Pandey et al 2009 and Ros et al 2018).[16,17] These health advantages, which include anti-aging, anti-carcinogenic, and anti-mutagenicity qualities are facilitated by the antioxidant activity linked to phenolic chemical(Vu Dc et al.,2018).[18] The total phenolic (TPC) and total antioxidant capacity (TAC) of walnut are substantially higher than those of almonds, hazelnuts, cashews, and peanuts among tree nuts(Wu X et al 2004).[19]

Materials And Methods

Materials

The wheat flour (*Triticum aestivum*),chia seeds(*salvia hispanica*),Flax seeds (*linum usitassimum*), walnut (*juglans hispanica*) and salt are purchased from the local market in salem Tamil Nadu. To exclude foreign material, The materials that were gathered were properly cleaned. Grain and nuts, including wheat, chia seeds, flax seeds and walnut were grounded into fine flour and its stored in zip lock cover for future usage.

Formulation of pasta

Four different propositions (0.5%,1%,1.5% and 2%) of omega 3 flour such as Chia seeds, Flax seeds and walnut were used to partially substitute wheat flour with pasta formulation. Each variation included sufficient amount of salt and water. In Total,13 different formulation were developed along with a control sample given in Table 1. All the dry ingredient were Mixed for 10 minutes to ensure uniform mixing and ingredient distribution The different dough was then extruded using a pasta machine Dolly La Monferrina pasta extruder chamber (Italy) to obtain the desired shapes.

Table-1: Formulation of Omega 3 enriched Pasta

Variation	Pasta variations Coding	Wheat flour (g)	Chia seeds	Flax seeds	Walnut	Salt and Water
Control	CP	100	-	-	-	As Required
Chia seeds Pasta	CSP1(0.5%)	97	3	-	-	As Required
	CSP2(1%)	94	6	-	-	As Required
	CSP3(1.5%)	91	9	-	-	As Required
	CSP4(2%)	88	12	-	-	As Required
Flax seed pasta	FSP1(0.5%)	97	-	3	-	As Required
	FSP2(1%)	95	-	5	-	As Required
	FSP3(1.5%)	93	-	7	-	As Required
	FSP4(2%)	91	-	9	-	As Required
Walnut pasta	WNP1(0.5%)	94	-	-	6	As Required
	WNP2(1%)	89	-	-	11	As Required
	WNP3(1.5%)	84	-	-	16	As Required
	WNP4(2%)	79	-	-	21	As Required

Cooking quality of pasta

Cooking quality of pasta was determined by minimal cooking time, water absorption, volume expansion and swelling index according to (Piwinska et al 2015 and Piwinska et al 2016).[21,22]

The colour evaluation

The Lovibond Tintometer model-LC 100 (United Kingdom) was used to measure the colour profile of dry pasta the measurement identified L*, a* and b*'s chromatic coordinates. The brightness (black to white) was specified by a coordinate L* in the range of 0 to 100. The yellowness-blueness balance was determined by the coordinate b*, which was in-plus for yellow and in-minus for blue. The coordinates b*, which were in-plus for yellow-blueness and in-minus for blue, balanced with illumination D65. .For every sample measurement were made in four replicates.

Sensory evaluation

A panel of 10 Semi trained judges used a 9 point hedonic scale to evaluate the sensory quality of all the developed pasta depending on appearance, color, taste, texture, flavor, and overall acceptability. A score card with score ranging from 1 to 9 was used, where 1 means really dislike, 5 means neither like nor dislike, and 9 means really like. The panelists were shown the coded sample in a random order.

Statistical analysis

Analysis of variance (ANOVA) was performed on the SPSS statistical tool and best variations were identified by comparing the means using Duncan's multiple range tests at 0.05% significance.

Result And Discussion

Cooking quality parameters of omega-3-enriched pasta

The cooking characteristic of omega-3 enrich pasta formulation were evaluated based on cooking time, water absorption, swelling index and volume expansion given in Table 2**.**The optimal cooking time ranged from 9.02 to 10.92 minutes, with the longest time observed in CSP3 and the shortest in FSP4 the slight increase in cooking time for some formulation may be attributed to the fibrous and nature of omega-3 added source, which can slow water penetration and gelatinization. Addition of soybean protein isolated up to 20% to wheat flour increased the cooking time of spaghetti. According to the American association of cereal chemists approved method 66-50, the ideal cooking time (OCT) was Ascertained(Vu Dc et al., 2018).[18] Water absorption ranged from Lower in WNP3 and higher in CSP3.The high water absorption in chia based sample, especially CSP3, may be due to the hygroscopic and mucilage-forming properties of chia seeds, which are known to hold water effectively. Using the methodology described in the study by(Wu X et al., 2004).[19], the water absorption of pasta was examined**.** The swelling index showed a declining trend with the incorporation of omega-rich ingredients, indicating reduced starch availability or dilution of starch dietary fiber and fat. the control pasta had the highest swelling index, while WNP4 showed the lowest .Based on the methods presented in (AACC 2000).[20],the swelling index was calculated 10g sample of dried and fresh pasta were cooked within the specified ideal cooking time. Volume expansion ranged from decreased in CSP2 and increased in FSP1 .Most flaxseed and walnut based pasta exhibited better volume expansion compared to the control, possibly due to their structural changes during cooking, promoting water uptake and matrix softening. The result suggest that the inclusion of omega-3 rich ingredients such as chia seeds, flax seeds, and walnuts significantly influences Pasta cooking behavior. While chia seed-enriched variants showed superior water absorption, flaxseed and walnut formulations contributed to better volume expansion. Making them promising functionalalternatives for conventional pasta fifteen different types of traditional pasta produced by various procedure and weight increase ranging from 2.62 to 3.00 (Nilusha et.al., 2019).[23]

Table-2: Cooking quality of omega 3 enrich pasta

Pasta Variations	Cooking time	Water absorption	Swelling index	Volume expansion
Control	09.94 ± 0.42^{abc}	130.00 ± 13.11^{c}	0.87 ± 0.08^{g}	0.47 ± 0.01^{abc}
CSP1	10.19 ± 0.28^{abc}	132.00 ± 15.74^{c}	0.77 ± 0.04^{fg}	0.50 ± 0.02^{abc}
CSP2	10.46 ± 0.60^{bc}	128.10 ± 03.29^{c}	0.70 ± 0.08^{ef}	0.39 ± 0.09^{a}
CSP3	10.92 ± 0.31^{c}	160.33 ± 11.78^{d}	0.58 ± 0.01^{cd}	0.44 ± 0.11^{ab}
CSP4	09.73 ± 0.40^{abc}	122.20 ± 08.22^{abc}	0.55 ± 0.05^{cd}	0.63 ± 0.07^{d}
FSP1	10.06 ± 0.60^{abc}	124.50 ± 08.22^{bc}	0.64 ± 0.01^{de}	0.66 ± 0.04^{d}
FSP2	09.29 ± 0.75^{ab}	118.03 ± 07.82^{abc}	0.56 ± 0.03^{cd}	0.63 ± 0.03^{d}
FSP3	10.13 ± 0.96^{abc}	107.63 ± 09.34^{ab}	0.50 ± 0.07^{bc}	0.55 ± 0.09^{bcd}
FSP4	09.02 ± 0.45^{a}	119.33 ± 09.73^{abc}	0.48 ± 0.03^{bc}	0.64 ± 0.03^{d}
WNP1	10.19 ± 0.91^{abc}	119.87 ± 14.20^{abc}	0.50 ± 0.02^{bc}	0.54 ± 0.07^{bcd}
WNP2	09.29 ± 1.08^{ab}	125.43 ± 03.53^{bc}	0.40 ± 0.01^{b}	0.56 ± 0.06^{bcd}
WNP3	09.48 ± 0.45^{ab}	104.06 ± 04.19^{a}	0.40 ± 0.04^{b}	0.58 ± 0.08^{cd}
WNP4	09.62 ± 0.42^{ab}	120.37 ± 15.10^{abc}	0.28 ± 0.15^{a}	0.64 ± 0.06^{d}

Significant differences in the means of cooking quality from CSP1 to WNP4 of the omega-3 enriched pasta are shown by different superscripts ^{abcdefg} in the same column ($p < .05$).

Colour value of omega 3 enriched pasta

The important indicators of pasta quality is its color. When taking into account the outcome of the dry and pasta color coordinates in Table 3, it primarily depends on the raw material utilized for pasta creation. The values L*, a*, and b* can be used to determine color changes in noodles and other food items. (Giada M. 2010).[3] states that the noodles' brightness level is determined by the L* value, their greenish color is determined by the a* value, and their yellow color is reflected by the b* value. The consistency of cooked pasta has been shown to be impacted by changes in starch after high-temperature drying., as proposed by Thus the samples colour value, determined using the lovibond tintometer, varied slightly. Lightness (L*) was lower in WNP2 which means the pasta was darker in colour and the control and FSP1 is highest value which represent light colour of the pasta seeming. The yellowness (b*) and redness (a*) values did not change, however WNP2 displayed somewhat greater values due to the dark colour of sample. Additionally consistent across samples were hue angle (h*) and (c*) suggesting stable colour tones and minor darkening and enhanced colour intensity generated by addition of omega rich flour.

Table-3: Colour value of omega 3 enriched pasta

Pasta Variations	L*	a*	b*	c*	h*
Control	75.43±0.70^{e}	4.83±1.53^{a}	15.90±0.88^{ab}	16.66±1.20^{a}	73.23±4.32^{a}
CSP1	73.13±1.35^{abcde}	4.46±1.42^{a}	14.93±0.87^{a}	15.60±1.22^{a}	73.56±4.19^{a}
CSP2	71.50±1.30^{ab}	4.40±1.47^{a}	15.16±0.98^{a}	15.83±1.35^{a}	73.96±3.86^{a}
CSP3	72.10±1.15^{abc}	4.33±1.53^{a}	15.43±0.92^{ab}	16.03±1.35^{a}	74.56±4.35^{a}
CSP4	71.90±1.45^{ab}	4.33±1.53^{a}	15.30±0.87^{ab}	15.90±1.21^{a}	74.43±4.31^{a}
FSP1	75.30±0.72^{de}	4.90±1.64^{a}	15.90±0.87^{ab}	16.63±1.36^{a}	73.10±4.15^{a}
FSP2	74.66±1.40^{cde}	5.23±1.62^{a}	16.10±1.03^{ab}	17.00±1.47^{a}	72.16±3.93^{a}
FSP3	74.16±0.89^{bcde}	5.46±1.67^{a}	16.36±0.98^{ab}	17.30±1.47^{a}	71.80±4.08^{a}
FSP4	73.30±1.08^{abcde}	5.40±1.64^{a}	15.63±1.10^{ab}	16.56±1.58^{a}	71.23±3.94^{a}
WNP1	72.63±2.57^{abcd}	5.33±1.62^{a}	15.36±0.90^{ab}	16.30±1.34^{a}	71.16±4.38^{a}
WNP2	70.93±2.33^{a}	6.06±1.77^{a}	17.16±1.26^{b}	18.26±1.76^{a}	70.70±3.77^{a}
WNP3	74.66±0.80^{cde}	5.13±1.53^{a}	14.90±0.87^{a}	15.80±1.38^{a}	71.23±4.10^{a}
WNP4	74.83±1.20^{de}	5.26±1.67^{a}	15.30±1.04^{ab}	16.20±1.56^{a}	71.16±4.24^{a}

Significant differences in the means of color values from CSP1 to WNP4 of the omega-3 enriched pasta are shown by different superscripts abcde in the same column ($p < .05$).

Nutrient value of omega 3 enriched pasta

The Table-4a,4b and 4c shows the nutrient composition of pasta formulation enriched with Chia Seeds Pasta (CSP1-CSP4) Flax Seeds Pasta (FSP1-FSP4),and Walnuts Pasta (WNP1-WNP4) was analyzed and compared with control sample. A gradual enrichment of these functional ingredients led to a consistent increase in energy value, ranging from 340 Kcal in the control to 405.95 kcal in WNP4, mainly due to increased fat content contributed by the lipid-rich nature of chia, flax and walnut component. Protein content exhibited a modest rise across all enriched sample, from 12.1 g in the control to 12.75 g in WNP4, while fat content increase sustainably from 1.9g (control) to 15.21 g in WNP4, with walnut based pasta showing the highest lipid levels due to the presence of heart-healthy polyunsaturated fat. The dietary fiber content increased in chia and flax formulation reaching up to 14.8g in CSP4, while walnut-based sample showed slightly lower values (11.05-11.87g), reflecting difference in fiber content of the ingredients. Significant improvements were also seen in mineral content .Calcium increased from 34 mg in the control to 105.64 mg in CSP4 owing to the calcium-rich nature of chia seeds. Phosphorus level peaked at 411.2mg in CSP4, while zinc showed a slight but consistent rise across all formulation. Iron content increased in chia and flax based pasta with CSP4 recording 5.23 mg. Compared to 4.9mg in the control, where WNP4 had slightly lower iron at 4.48mg. In terms of vitamin content, modest improvement were recorded in vitamin A(up to 2.14 µg in CSP4).Vitamin C(up to 0.27 mg in WNP4) and B-complex vitamins such as thiamin(B1) and niacin (B3).Although riboflavin (B2) remained consistent at 0.15 mg across all sample, thiamin ranged from 0.43 to 0.56 mg, and niacin decreased slightly in walnut variants(4.35 mg in WNP4) possibly due processing or dilution effects. Notably the inclusion of omega-rich ingredient led significant enrichment in folic acid, with the highest value observed inWNP4 (49.02) compared to 36 µg in the control. Sodium content increased slightly in CSP and FSP sample due to natural and additives sources but remained low and Consistent in walnut based formulation. Importantly, omega-3 fatty acid (alpha-linolenic acid, ALA) content increased remarkably in all enriched variants. While the control contained no detectable ALA, CSP4, FSP4 and WNP4 contained 2.14g, 2.05 and 1.91 g. respectively, confirming the effectiveness of chia, flaxseed, and walnut flour in enhancing the functional lipid profile of pasta. These finding validates the nutritional benefits of fortifying pasta with omega-3-rich plant based ingredients for the development of value added functional foods.

Table-4a: Nutrient value of omega 3 enriched chia seeds pasta

Nutrient	Control	CSP1	CSP2	CSP3	CSP4
Energy (Kcal)	340	343.4	348.8	353.1	357.5
Protein (g)	12.1	12.23	12.36	12.5	12.63
Fat (g)	1.9	2.78	3.63	4.49	5.35
Fiber (g)	12.2	12.92	13.53	14.2	14.87
Zinc (mg)	2.6	2.67	2.72	2.78	2.84
Calcium (mg)	34	52.5	69.82	87.73	105.64
Phosphorus (mg)	350	362.4	380.6	395.9	411.2
Vitamin A (µg)	0	0.48	0.96	1.44	1.92
Thiamin (B1) (mg)	0.45	0.456	0.46	0.47	0.47
Riboflavin (B2) (mg)	0.15	0.151	0.15	0.16	0.15
Niacin (B3)	5.2	5.3	5.42	5.53	5.64
Vitamin C (mg)	0	0.048	0.1	0.14	0.19
Iron (mg)	4.9	4.99	5.07	5.15	5.23
Folic Acid(µg)	36	36.4	36.78	37.17	37.56
Sodium (mg)	2	2.42	2.84	3.26	3.68
Omega-3 (ALA)	0	0.534	1.07	1.6	2.14

Table-4b: Nutrient value of omega 3 enriched flax seeds pasta

Nutrient	Control	FSP1	FSP2	FSP3	FSP4
Energy (Kcal)	340	345.8	349.7	353.6	357.5
Protein (g)	12.1	12.28	12.41	12.53	12.66
Fat (g)	1.9	3.11	3.92	4.72	5.53
Fiber (g)	12.2	12.65	12.96	13.26	13.56
Zinc (mg)	2.6	2.65	2.69	2.72	2.76
Calcium (mg)	34	40.63	45.05	49.47	53.89
Phosphorus (mg)	350	358.8	364.6	370.4	376.3
Vitamin A (µg)	0	0	0	0	0
Thiamin (B1) (mg)	0.45	0.49	0.51	0.53	0.56
Riboflavin (B2) (mg)	0.15	0.15	0.15	0.15	0.15
Niacin (B3)	5.2	5.13	5.09	5.04	5.01
Vitamin C (mg)	0	0.018	0.03	0.042	0.054
Iron (mg)	4.9	4.92	4.95	4.96	4.97
Folic Acid(µg)	36	37.53	38.55	39.57	40.59
Sodium (mg)	2	2.84	3.4	3.96	4.52
Omega-3 (ALA)	0	0.68	1.14	1.6	2.05

Table-4c: Nutrient value of omega 3 enriched walnut pasta

Nutrient	Control	WNP1	WNP2	WNP3	WNP4
Energy (Kcal)	340	358.84	374.54	390.24	405.94
Protein (g)	12.1	12.28	12.44	12.59	12.75
Fat (g)	1.9	5.7	8.86	12.03	15.21
Fiber (g)	12.2	11.87	11.6	11.32	11.05
Zinc (mg)	2.6	2.63	2.65	2.68	2.7
Calcium (mg)	34	37.84	41.04	44.24	47.44
Phosphorus (mg)	350	349.8	349.6	349.4	349.2
Vitamin A (µg)	0	0.06	0.11	0.16	0.21
Thiamin (B1) (mg)	0.45	0.44	0.44	0.43	0.43
Riboflavin (B2) (mg)	0.15	0.15	0.15	0.15	0.15
Niacin (B3)	5.2	4.96	4.75	4.55	4.35
Vitamin C (mg)	0	0.078	0.14	0.21	0.27
Iron (mg)	4.9	4.79	4.68	4.6	4.48
Folic Acid(µg)	36	39.72	42.82	45.92	49.02
Sodium (mg)	2	2	2	2	2
Omega-3 (ALA)	0	0.54	1	1.45	1.91

Sensory analysis of omega 3 enriched Pasta

The sensory evaluation showed that the control CSP treated sample differed significantly in every attributed that was assessed. Strong panelist preference was shown by the control samples constant highest values for appearance, Flavor and overall acceptability. with scores for appearance and colour that were better than the control, as well as a high taste score in CSP2 demonstrated the most promising outcome among the treatment. Although it was slightly lower than the control, its overall acceptance was still good. With an overall acceptance of CSP1 performed well in every category, particularly in the taste and flavor.

The lower overall acceptability rating form CSP3 and CSP4 may have been due to their slightly decreased scores, especially in flavor and taste (Fig 1).When Compared to control, the sensory evaluation of the FSP treated sample revealed significant variations in quality features. All metrics showed the greatest result for the control sample, with very high rating for overall acceptability, taste and appearance and when the addition of omega percentage increased the score slightly decreased. FSP2 and FSP3 and exhibited comparatively superior sensory performance among the FSP treatment (Fig 2) **.**When compared to the control, the sensory evaluation of WNP- treated samples showed slight variation across all evaluated parameters. ratings for flavor, Taste and overall acceptability score were increased with decreased percentage and Slightly decreased with increase percentage (Fig 3)**.**

Figure 1: Radar graph of omega 3enriched Chia Seed Pasta

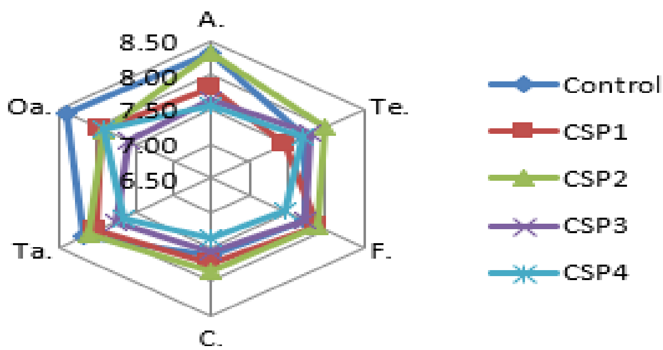


Figure 2: Radar graph of omega 3 enriched Flax Seed Pasta

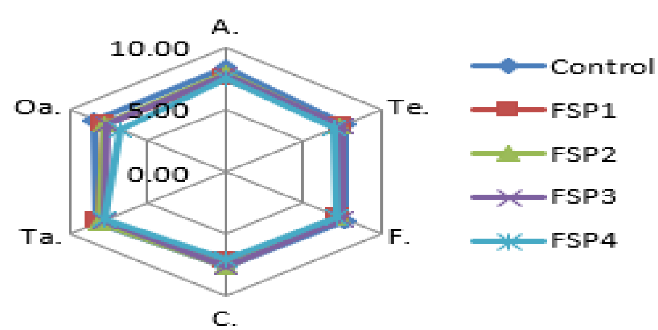
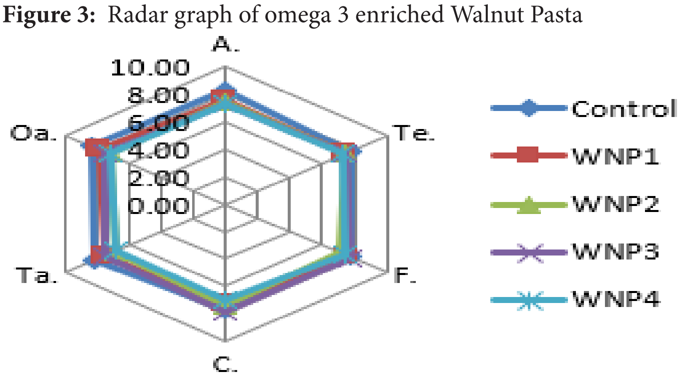


Figure 3: Radar graph of omega 3 enriched Walnut Pasta



Conclusion

The current study showed that adding omega-3 rich items, such, chia seeds, flaxseeds and Walnut to pasta greatly improved its nutritional profile by raising its levels of protein, dietary fiber, alpha-linolenic acids (ALA), minerals and vitamins. The addition of these functional additives affected cooking quality metrics such as cooking duration water absorption, swelling index and volume expansion, but overall cooking performance stayed within acceptable bounds, Sensory analysis revealed that while the control sample were frequently rated highest for overall acceptability, flavor, taste, texture and appearance, similar sensory characteristics were shown by a number of enriched formulation, most notably CSP2 (chia seeds)and WNP1 (walnut). The effect of omega-3 enrichment on pasta quality was validated by statistical analysis employing a one-way ANOVA and Duncan's multiple Range Test ($p<0.05$), which verified significantly difference across treatment for the majority of metrics. Hence, omega 3 enrich pasta with majority desirable characteristic from (CS),(FS) and (WN) powder, it is recommended that the 2 percentage of incorporated omega 3 (CS),(FS) and (WN) in the formulation of pasta, According to these results of pasta boosted with omega 3 can provided more nutritional benefits without significantly compromising flavor, which makes it a viable option for the creation of functional foods aimed at consumers who are health in conscious.

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Conflicts Of Interest /Competing Interests

No conflicts of interest are disclosed by the authors.

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