IJFANS
International Journal of Food And Nutritional Sciences

Volume 7, Issue 4, October 2018, www.ijfans.com e-ISSN: 2320-7876

# INTERNATIONAL JOURNAL OF FOOD AND NUTRITIONAL SCIENCES

## IMPACT FACTOR ~ 1.021

Official Journal of IIFANS

IJFANS International Journal of Food and Nutritional Science

*e-ISSN 2320 -7876 www.ijfans.com*
*Vol. 7, No. 4, October 2018*
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***Research Paper*** ***Open Access***

# DEVELOPMENT OF VALUE ADDED VERMICELLI FROM MALTED PEARL MILLET AND PSYLLIUM HUSK FLOURS

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Received on: 26th June, 2018 Accepted on: 3rd August, 2018

An attempt to develop a value added ready-to-cook convenience food 'vermicelli' was carried out using malted pearl millet (*Pennisetum glaucum*) and psyllium husk (Isbagol) flours. Results of the study revealed that malting pearl millet significantly improved physical, chemical and nutritional qualities along a desirable reduction in anti-nutrient property when compared with raw/unprocessed pearl millet. Psyllium husk possess 1.66 g of natural soluble fiber and its gel-like character in water contributes a significant role in extrusion process of vermicelli production made from pearl millet which is gluten free. Formulation of composite flour mixtures for development of vermicelli were done by keeping malted pearl millet flour as the base and incorporating psyllium husk flour in three different variations. The homogenized flour mixtures were added with adequate salt and water to make dough and extruded into vermicelli strands and then dried. Textural analysis of cooked vermicelli revealed that there were significant textural improvement after malting process when compared with similar variations made from raw pearl millet and psyllium husk combinations. Regarding sensory evaluation, all the developed vermicelli variations were well acceptable with overall acceptability scores ranging from 8.30 to 7.60 on a 9 point hedonic scale when compared with the standard vermicelli made from refined wheat flour. This study further demonstrates an insight that malting significantly improved the functional quality of pearl millet flour thereby making it compatible with higher proportion (30%) of psyllium husk incorporation with overall sensory acceptability being on par with the standard vermicelli. While, vermicelli made from raw pearl millet flour with lesser proportion (10%) of psyllium husk incorporation could only match up with the standard vermicelli. Thus this study creates an opportunity to successfully malt pearl millet and develop value added vermicelli with incorporation of higher proportion of psyllium husk and also promote its consumption among the health conscious genera of today's world and receive multiple health benefits.

***Keywords:*** Pearl millet, Malting, Psyllium husk, Vermicelli, Texture analysis, Sensory evaluation

## INTRODUCTION

Pearl millet (*Pennisetum glaucum*) commonly known as Bajra is one of the most widely grown millet and is also called as poor man's grain. It is one of the most nutritious millet and has a substantive potential in the food basket for improved food and nutrition security (Mal *et al*., 2010). Pearl millet is a good source of energy and protein in the diet and also rich in essential minerals and dietary fiber. Besides these nutrients they also contain certain phytochemicals with neutraceutical properties and hence are also termed as 'nutricereal'. In spite of the amazing nutritional significance, certain anti-nutrients present in pearl millets could limit its

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bio-availability in human gut. But many home scale processing methods like malting may reduce the level of anti-nutrients and improve its digestibility, sensory and nutritional quality (Sarita and Ekta, 2017). Thus processing pearl millets with simple and easy procedures not only enhances its nutritional bioavailability and usage at household level, but may also encourage food processors to develop ready-to-use or ready-to-eat pearl millet based convenience food products in market.

Today, with changing life style and greater awareness on health, there is growing interest among people on value added foods with maximum health benefits (functional foods). Psyllium husk (*Isabgol*) is well known natural dietary fiber widely used from times of Ayurveda. It is acclaimed for nutraceutical and medicinal values and can be incorporated into foods for value added health benefits, with an added advantage being highly biocompatible, cheap and easily available in India (Dhiman *et al*., 2012). Psyllium husk has no nutritive value other than as a dietary fiber source (Karawya, 2003) and can swell 10-14 times of its original volume, which naturally contributes to desirable properties like enhanced thickness and binding. This property had led to its utilization in food processing industries in the production of food products like ice creams and frozen desserts, breakfast cereals, bakery products like biscuits, cakes, breads and muffins with varying functional and health benefits (Zia *et al.*, 2005).

Vermicelli is a popular, convenience and ready to cook food product developed by extrusion process. It is very much liked by people from all walks of life, irrespective of age and consumed as breakfast, snack and dessert item, especially in south India. Various studies have been reported on developing extruded food products from pearl millet like, pasta from pearl millet and fenugreek seeds (Archana, 2001), pearl millet vermicelli with wheat and chick pea flour (Dod *et al.*, 2003), de-pigmentation of pearl millet flour on pasta (Rathi *et al*., 2004), effect of hydrocolloids on ready to cook gluten free pearl millet vermicelli (Hymavathi *et al*., 2014) and ready to eat pearl millet based extruded snacks (Isha and Raj, 2017).

Since there were no studies found in literature on vermicelli made exclusively from pearl millet with a health value addition of psyllium husk incorporation, the present study was under taken: (i) to formulate and develop value added vermicelli from malted pearl millet flour incorporated with psyllium husk flour in three different proportions, (ii) to study the textural and sensory properties of the developed vermicelli.

## MATERIALS AND METHODS

Pearl millet grains (*P.glaucum*-Co4 variety) were purchased from local market and psyllium husk were purchased from Gujarat, India. Pearl millets were placed in a tray, examined and cleaned for chaff and damaged grains, stones/pebbles and all other extraneous matter and discarded. They were soaked overnight and next day, drained off water and the seeds were tied in a muslin cloth and hung in humid atmosphere. Germination process was allowed for 48 hours and the seeds were shade dried and Milled to Pearl Millet Flour (MPMF). Raw/unprocessed Pearl Millet Flour (RPMF) was used as control sample. The procured psyllium husk were cleaned and powdered into fine Psyllium Husk Flour (PHF).

### Physico-Chemical Analysis

Pearl millets were analyzed for physical properties using standard procedures with slight modification to the method of Wani *et al.* (2013) and the chemical compositions of MPMF, RPMF and PHF were carried out using AOAC (1995) standard methods.

### Preperation of Vermicelli

The MPMF and RPMF were individually mixed with PHF in 3 different variations such as, 90:10 (V1), 80:20 (V2) and 70:30 (V3) respectively. The formulated composite flour mixtures were homogenized and mixed with required salt and water to prepare dough. It was then extruded to make vermicelli strands (MPMFV and RPMFV) which were steamed for few minutes, dried at room temperature for 1 Hr and then dried (cabinet drier) at 60ºc for 4 Hrs.

### Texture Analysis

An objective textural evaluation of the developed vermicelli variations were studied using Texture Profile Analysis (TPA) method and TA Perten Instruments TVT 6700 texture analyzer were used to measure the textural properties, where each vermicelli sample were placed in loading cell and compressed as per the standard procedure given by Singh *et al.* (1993).

### Sensory Evaluation

A subjective evaluation of the developed vermicelli variations for sensory attributes like appearance, flavor, color, texture, taste and overall acceptability study were done by

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a panel of 25 semi-trained judges using a 9 point hedonic scale, on comparing with refined wheat flour vermicelli (V0; RWFV) as standard vermicelli sample.

### Statistical Analysis

The data tabulated and reported in the results are the average of triplicate observations. Statistical analysis of the results was done with Microsoft Excel 2007 (Microsoft Inc., USA) and Duncan's test was applied to determine significant differences among mean values.

## RESULTS AND DISCUSSION

### Physical Properties of Pearl Millet

The physical properties of pearl millet (Table 1) showed a significant increase during malting on most of the parameters studied, which reveal an improved physical and functional property after malting. Thousand grain weight (7.42%) and grain volume (7.22%) increased in malted pearl millet which can be positively correlated with an increase in protein content during germination process (Sachan and Singh, 2001). Hydration Capacity (HC), Oil Absorption Capacity (OAC) and Water Absorption Capacity (WAC) also increased in malted pearl millet which suggests good reconstitution ability of the flour to make dough and enhance its properties. A higher WAC corresponds to loss in structure of starch polymers (during malting), resulting in higher soluble sugars and proteins (Akubor and Badifu, 2004). Higher OAC suggests presence of apolar amino acids, indicating that reserves of nutrients like protein and starch have been respectively degraded to meet seedling requirements during germination process (Claver *et al.*, 2010). Swelling capacity had also significantly increased in malted pearl millet (5.03) than control (0.21). Better swelling capacity signifies enhanced flour functionality, which would ultimately yield a good food product (Adebiyi *et al.*, 2016).

### Chemical Composition of Pearl Millet

The chemical composition of pearl millet (Table 2) revealed that the pH concentration slightly declined in malted sample which may contribute in decreasing the mousy odour of pearl millet and enhance its palatability and keeping quality (Plembe *et al.*, 2004). Ash content significantly decreased in MPMF (1.4 g) when compared with RPMF (3.1 g). Reduction of ash content may be due to the leaching of soluble inorganic salts during wet processing methods like germination which was also reported by Sihag *et al.* (2015). Total titrable acidity decreased in MPMF (40.3) which may influence in good keeping quality. Moisture content increased in MPMF (10.12%) when compared with RPMF (8.88%) which can be attributed to the moist processing method involved in this study. However, moisture content of both samples were found to be less than the maximum moisture content limit (13%) for pearl millet flours as recommended by FAO/WHO (2007).

Regarding proximate compositions (Table 2), major malting effect was observed on protein, fat and carbohydrate contents. A remarkable increase in crude protein content of MPMF (14.6%) were noted when compared with RPMF (8.2 g). Similar findings have also been reported by Inyang and Zakari (2008) and Kindiki *et al.* (2015), which attributes to

**Table 1: Physical Properties of Pearl Millet**

| S. No. | Parameters (%) | Raw Pearl Millet | Malted Pearl Millet |
|---|---|---|---|
| 1 | Thousand grain weight | 7.26±0.005 | 7.42±0.12 |
| 2 | Thousand grain volume | 7.01±0.02 | 7.22±0.21 |
| 3 | Hydration capacity | 5.0±0.005 | 5.12±0.55 |
| 4 | Oil absorption capacity | 1.25+-0.03 | 1.47+-0.02 |
| 5 | Water absorption capacity | 1.27±0.04 | 1.46±0.03 |
| 6 | Swelling capacity | 0.21±0.02 | 5.03±0.4 |

**Table 2: Chemical Composition of Pearl Millet Flour**

| S. No. | Parameters | Raw Pearl Millet Flour | Malted Pearl Millet Flour |
|---|---|---|---|
| 1 | Ph | 7.2±0.21 | 7.1±1.32 |
| 2 | Ash (g) | 3.1±0.11 | 1.4±0.21 |
| 3 | Total titrable acidity | 43.3±2.21 | 40.3±2.27 |
| 4 | Moisture (%) | 8.88±1.34 | 10.12±2.27 |
| 5 | Crude Protein (g) | 8.2±2.4 | 14.6±1.84 |
| 6 | Fat (g) | 2.4±1.24 | 2.1±1.03 |
| 7 | Carbohydrates (g) | 85±2.47 | 78±2.27 |
| 8 | Crude Fiber (g) | 4.7±1.02 | 4.9±1.10 |
| 9 | Energy (K.cal) | 394.4±25.14 | 389.3±24.10 |

the activity of enzymatic proteins within seeds in the process of breaking down proteins into amino acids during germination. Regarding fat content, reduction in MPMF (2.1 g) were observed which may be due to utilization of fats in the sprouting process for energy, and similar observation was reported by Shah *et al*. (2011). Regarding carbohydrates, MPMF (78 g) showed a decline than RPMF (85 g), because of the fact that carbohydrate enzymes during malting have dextrinified starch to soluble sugars, but this conversion is considered advantageous in respect of improving nutritional density. Fasasi (2009) and Researchers Gernah *et al*. (2011) also reported less bulky flours after malting but had enhanced nutritional density. Regarding crude fiber, MPMF (4.9 g) showed slight increase than RMPF (4.7 g) which was also reported by Kindiki *et al*. (2015). The Energy content of MPMF (389.3 Kcal) were marginally less than RPMF (394.4) and this result can be attributed to the reduction in fat and carbohydrate content during malting process. Nevertheless, the process of malting had significantly improved the nutritional quality of pearl millet by enhancing easily available carbohydrates and amino acids which can be easily digested and bioavailable, while a reduction in fatty acids may positively increase the palatability of pearl millet based food products (Pelembe *et al*., 2002).

## Non-Nutrient Content of Pearl Millet

The non-nutrients studied were tannin, trypsin and total phenolic content (Table 3). Tannin and trypsin are important anti-nutrients in pearl millet which can form complexes with nutrients like proteins, carbohydrates and minerals in the human gut and thereby reduce their bioavailability (Dyke and Rooney, 2006). Results of this study revealed that, malting significantly reduced tannin levels (0.22 mg) when compared with RPMF (0.30 mg) and similar reports have also been documented by different researchers Hithamani and Srinivasan (2014), Isha and Raj (2017), and Sarita and Ekta (2017). There exists a strong relationship between tannin levels and protein digestibility (Nambiar *et al.*, 2011) and also a decrease in tannin level positively increases protein digestibility (Irene Leder, 2004). Similarly, anti-nutritional activity of trypsin inhibitor were also reduced from 0.14 mg in RMPFV to 0.10 mg in MPMFV which could be attributed to its utilization during germination (Kirti *et al*., 2016). Trypsin inhibitor activity could also contribute to the development of bad odour during long periods of food storage and its reduction may considerably aid in improving palatability and keeping quality of pearl millets.

**Table 3: Non-Nutrient Content of Pearl Millet Flour**

| S. No. | Parameters | Raw Pearl Millet Flour | Malted Pearl Millet Flour |
|---|---|---|---|
| 1 | Tannin (mg)s | 0.30±0.01 | 0.22±0.03 |
| 2 | Trypsin inhibitor (mg) | 0.14± 0.02 | 0.10 ±0.01 |
| 3 | Total Phenols (mg) | 58.6±1.14 | 62.4±2.18 |

Total phenolic content is a desirable non-nutrient property which reveals anti-oxidant potency in foods. Results indicated that (Table 3) total phenolic content increased in MPMF (62.4 mg) when compared with RPMF (58.6 mg) which positively relates to improved anti-oxidant activity after malting, also reported by Thippuswamy and Akilendar (2005). Pearl millets are a potential source of antioxidants in diet because of its high total phenolic content (Shahidi and Chandrasekara, 2013). Presence of anti-oxidants in foods have been identified as having medicinal properties that extends its role as a functional food which may impact positively on overall health and wellbeing (Arya *et al*., 2013).

## Chemical Composition of Psyllium Husk Flour

The chemical composition (Table 4) of psyllium husk flour were observed that it contained 73.96 g of carbohydrates, 1.69 g of dietary fiber (1.66 g of soluble and 0.03 g of insoluble fiber) and 273.33 Kcal of energy. Psyllium husk is a white fibrous hydrophilic material, produced mainly for its mucilage content. A unique physiological property of psyllium husk fiber is its high viscosity and gel-like character in water which plays a significant role in many food processing and production industries. And the presence of this abundant natural soluble fiber promises multiple health benefits when consumed in the diet and could play a

**Table 4: Chemical Composition of Psyllium Husk Flour**

| S. No. | Parameters | Psyllium Husk Flour |
|---|---|---|
| 1 | Carbohydrates (g) | 73.96 ± 2.95 |
| 2 | Dietary fiber (g) | 1.69 ± 0.07 |
| 3 | Insoluble fiber (g) | 0.03 ± 0.02 |
| 4 | Soluble fiber (g) | 1.66 ± 0.05 |
| 5 | Energy (K.cal) | 273.33 ± 3.78 |

significant role in therapeutic applications as well (Anjali and Renu, 2015).

## Texture Analysis

Texture is an important characteristic quality in development of a new food product which gives a critical attribute in the overall acceptance of food. It is one of the main acceptability factor perceived by consumers to evaluate food. The results of texture analysis (Table 5 and Figure 1) revealed that, the hardness peak force of Raw Pearl Millet Flour Vermicelli (RPMFV) increased significantly with an increase in psyllium husk flour proportion while malted pearl millet flour (MPMFV) showed a consistent decline. However, hardness level of each MPMFV was higher when compared with the same variations with RPMFV. Hardness of vermicelli is dependent on the cell strength influenced by starch gelatinization and protein content (Yadav *et al*., 2014). Enhanced hardness observed in MPMFV could be attributed to the physiochemical changes happened during malting and also with the interaction of soluble fibers in psyllium husk, making the vermicelli compact. Regarding cohesiveness, MPMFV showed increased cohesiveness in $V_1$ (0.93) when compared with the similar formulation in RPMFV (0.77), and also an increasing trend was observed in $V_2$ and $V_3$ samples. MPMV showed better cohesiveness than RPMV which could be attributed to the physiochemical changes during malting process. Pearl millet is gluten free and less cohesive but value addition of psyllium husk compensates this property by increasing cohesiveness and extensive texture of the dough in extruding vermicelli. Regarding adhesiveness, all the MPMFV variations showed highest values when compared to RPMFV variations. Generally vermicelli with high scores of cohesiveness and adhesiveness is preferred as it gives a clean and smooth texture. Regarding stickiness, all the three variations in MPMFV were less sticky when compared with RPMFV formulations. Sticky nature of vermicelli is not preferred by consumers and so, lower levels are expected in vermicelli production. Pearl millet contains insoluble fiber and psyllium husk contains soluble fiber, along with this combination malting further improves the physicochemical properties of pearl millet which imparted good textural properties.

### Sensory Evaluation

Sensory evaluation is a perception using all senses in choosing or eating a food product. All the vermicelli variations of this study were subjected to sensory evaluation and were found to be well acceptable when compared with standard vermicelli (Refined Wheat Flour Vermicelli; RWFV) and overall acceptability ranged from 8.30 to 7.60 on a 9 point hedonic scale. Regarding Raw Pearl Millet Four Vermicelli (RPMFV) in comparison with the standard vermicelli (RWFV) in Table 6, appearance scores of $V_1$ and $V_2$ formulations were highest and similar (8.0), and also outstanding the standard sample $V_0$ (7.60). Flavour scores were relatively higher among all the variations of RPMFV in the order of $V_1$ (8.20) followed by $V_2$ (8.00) and $V_3$ (7.80) respectively when compared with the standard vermicelli ($V_0$:7.70). Regarding colour, varied scores were obtained among the samples, with $V_3$ scoring the highest (7.90) than other vermicelli variations. Regarding taste, standard vermicelli ($V_0$) received highest preference score and among the three variations of RPMFV, $V_3$ (8.10) tasted better than the others. Overall acceptability of the developed RPMFV revealed that, the formulated $V_1$ variation was highly acceptable and had the same score (8.30) as that of the standard ($V_0$), followed by $V_3$ and $V_2$, closely matching up to the sensory profile of standard vermicelli.

Regarding sensory evaluation of malted pearl millet vermicelli (MPMFV) in comparison with the standard vermicelli (Table 7), appearance scores were highest (7.80) and similar in $V_1$ and $V_3$ variations while relatively low

**Table 5: Texture Analysis of the Developed Vermicelli Variations**

| S. No. | | Hardness (N) | | Cohesiveness (Ratio) | | Adhesiveness (J) | | Stickiness (N) | |
|---|---|---|---|---|---|---|---|---|---|
| | | RMPFV | MPMFV | RPMFV | MPMFV | RPMFV | MPMFV | RPMFV | MPMFV |
| 1 | $V_1$ | 15.13 ± 0.008 | 76.29 ± 2.14 | 0.77 ± 0.01 | 0.93 ± 0.03 | 1324 ± 1 | 2284.3 ± 3.41 | -1.56 ± 0.01 | -2.62 ± 0.31 |
| 2 | $V_2$ | 39.43 ± 0.005 | 45.48 ± 1.37 | 1.06 ± 0.01 | 1.02 ± 0.01 | 1328.8 ± 0.57 | 5373.6 ± 2.47 | -1.92 ± 0.01 | -5.82 ± 0.2 |
| 3 | $V_3$ | 44.88 ± 0.15 | 28.42 ± 2.01 | 1.02 ± 0.15 | 1.12 ± 0.02 | 1960.9 ± 0.05 | 3611.4 ± 3.12 | -2.33 ± 0.015 | -4 ± 0.04 |

**Note:** RPMFV: Raw Pearl Millet Flour Vermicelli; MPMFV: Malted Pearl Millet Flour Vermicelli; $V_1$: Pearl Millet Flour PMF(90) : Psyllium Husk Flour-PHF(10); $V_2$: PMF(80) : PHF(20); $V_3$: PMF(70) : PHF(30).

**Figure 1: Textural Analysis of the Developed Vermicelli Variations**

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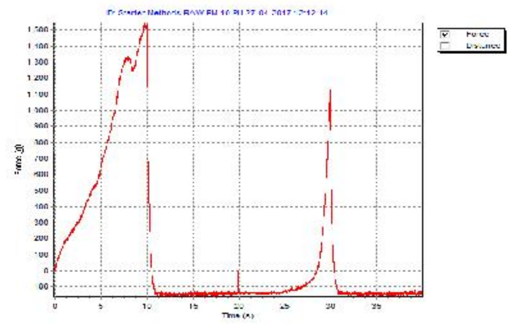
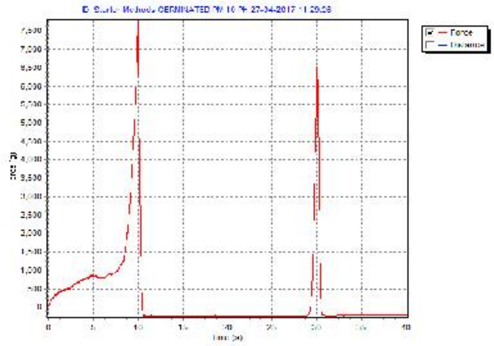
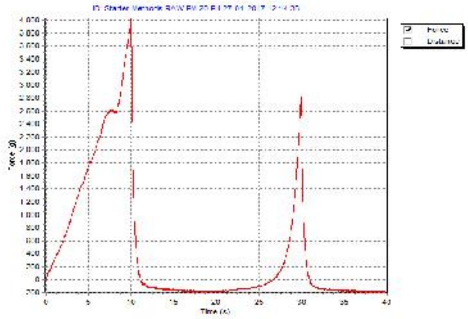


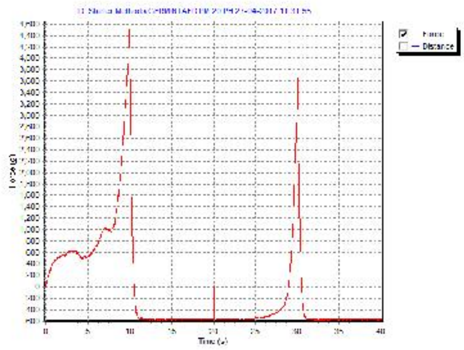
**RPMFV – V1**



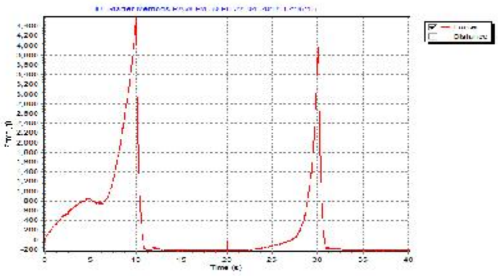
**MPMFV – V1**



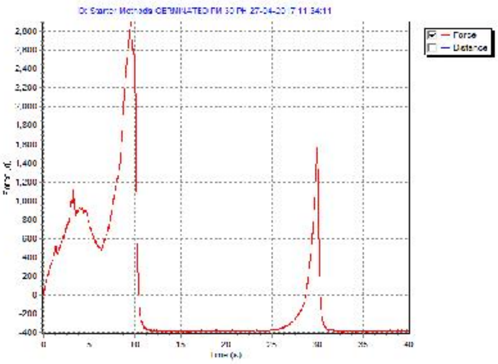
**RPMFV - V2**



**MPMF - V2**



**RPMFV – V3**



**MPMFV – V3**

**Note:** RPMFV: Raw Pearl Millet Flour Vermicelli; MPMFV: Malted Pearl Millet Flour Vermicelli; $V_1$: Pearl Millet Flour PMF(90) : Psyllium Husk Flour-PHF(10); $V_2$: PMF(80) : PHF(20); $V_3$: PMF(70) : PHF(30).

**Table 6: Sensory Evaluation of Raw Pearl Millet Flour Vermicelli (RPMFV)**

| Variation | Appearance | Flavour | Colour | Texture | Taste | Overall Acceptability |
|---|---|---|---|---|---|---|
| $V_1$ | $8 \pm 0.66^{abcde}$ | $8.2 \pm 0.78^{bcde}$ | $7.7 \pm 0.82^{abcde}$ | $8.1 \pm 0.73^{cdf}$ | $7.9 \pm 0.87^{abd}$ | $8.3 \pm 0.67^{bce}$ |
| $V_2$ | $8 \pm 0.47^{abcde}$ | $8 \pm 0.81^{abc}$ | $7.6 \pm 0.69^{abc}$ | $8 \pm 0.66^{abe}$ | $7.9 \pm 0.73^{abc}$ | $8.1 \pm 0.56^{ab}$ |
| $V_3$ | $7.5 \pm 0.70^{abcd}$ | $7.8 \pm 0.78^{abcde}$ | $7.9 \pm 0.87^{defg}$ | $8 \pm 0.94^{cdef}$ | $8.1 \pm 0.56^{cdef}$ | $8.2 \pm 0.63^{cde}$ |
| $V_0$ | $7.6 \pm 0.84^{bcde}$ | $7.7 \pm 0.67^{cde}$ | $7.8 \pm 0.91^{abcde}$ | $8.1 \pm 0.99^{cdef}$ | $8.2 \pm 0.63^{abc}$ | $8.3 \pm 0.67^{cde}$ |

**Note:** $V_1$: Raw Pearl Millet Flour; RPMF(90) : Psyllium Husk Flour; PHF(10); $V_2$: RPMF(80) : PHF(20); $V_3$: RPMF(70) : PHF(30); $V_0$: (100) Refined Wheat Flour Vermicelli (RWFV).

**Table 7: Sensory Evaluation of Malted Pearl Millet Flour Vermicelli (MPMFV)**

| Variation | Appearance | Flavour | Colour | Texture | Taste | Overall Acceptability |
|---|---|---|---|---|---|---|
| $V_1$ | $7.8 \pm 0.78^{abcde}$ | $7.7 \pm 0.82^{abcde}$ | $7.5 \pm 0.70^{bcde}$ | $7.6 \pm 0.84^{bcde}$ | $7.9 \pm 0.73^{bcdef}$ | $8 \pm 0.66^{bcd}$ |
| $V_2$ | $7.5 \pm 0.84^{de}$ | $7.8 \pm 0.63^{cde}$ | $7.2 \pm 0.91^{defg}$ | $7.2 \pm 0.78^{cdef}$ | $7.8 \pm 0.78^{abcd}$ | $7.6 \pm 0.84^{bcde}$ |
| $V_3$ | $7.8 \pm 0.78^{ab}$ | $7.9 \pm 0.73^{ab}$ | $8.1 \pm 0.73^{ab}$ | $8.1 \pm 0.99^{ab}$ | $8.2 \pm 0.63^{ab}$ | $8.3 \pm 0.67^{ab}$ |
| $V_0$ | $7.5 \pm 0.84^{de}$ | $7.9 \pm 0.73^{cde}$ | $7.5 \pm 1.08^{defg}$ | $8.3 \pm 0.82^{cd}$ | $8.2 \pm 0.78^{abc}$ | $8.3 \pm 0.82^{bcd}$ |

**Note:** $V_1$: Malted Pearl Millet Flour; MPMF(90) : Psyllium Husk Flour; PHF(10); $V_2$: MPMF(80) : PHF(20); $V_3$: MPMF(70) : PHF(30); $V_0$: (100) Refined Wheat Flour Vermicelli (RWFV).

but similar scores (7.50) were observed in $V_2$ and $V_0$ samples respectively. Regarding flavour attribute, $V_3$ scored the same as that of standard $V_0$ (7.90) and topped the scores than the other $V_1$ and $V_2$ variations. Regarding colour, $V_3$ scored highest (8.10) preference followed by $V_1$ and $V_0$ with similar (7.50) scores. Regarding texture, varied scores were obtained with $V_0$ being highest followed by $V_3$, $V_1$ and $V_2$ respectively. The overall acceptability of MPMFV revealed that $V_3$ (8.30) variation were highly acceptable among the other variations and scoring the same as the standard $V_0$ (8.30), followed by $V_1$ and $V_2$ vermicelli samples.

Comparing the sensory evaluation results of RPMFV and MPMFV variations, malting process significantly improved the desirable functional, sensory and palatable characteristics of pearl millets and also enhanced its potential to be incorporated with higher proportion (30%) of psyllium husk flour and yet scoring highest overall acceptability in par with the standard vermicelli. Nevertheless, though all the RPMFV formulations were acceptable with good scores, highest overall acceptability as same as that of the standard vermicelli were found only in lesser proportion (10%) of psyllium husk incorporation. Thus this study is promising in the production of value added food extruded products from pearl millet and psyllium husk combinations with enhanced nutritional, textural and sensory propertied.

## CONCLUSION

This study demonstrates the potential of malting pearl millet and incorporating it with psyllium husk for value addition in the development of ready-to-cook convenience food 'vermicelli' and create a tremendous opportunity to successfully promote its usage at house hold level and also encourage food processors to develop this millet based vermicelli with value added multiple health benefits.

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