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Use of *Halosarcia indica* (Willd.) Paul G. Wilson Extracts for Low Salted Dried Fish Production

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Abstract *Halosarcia indica* (Willd.) Paul G. Wilson (Chenopodiaceae) is an underutilized, succulent herb freely distributed in coastal areas. Although the plant is rarely used for human consumption, there is scattered information of its usage as a natural salt. Therefore, the present study was aimed to incorporate *H. indica* as a source of natural salt for the production of herbal salted dried fish to develop a cottage industry in coastal areas of Sri Lanka. Well matured, authenticated, *H. indica* plants were harvested and cleaned well. Then materials were ground and extracts were freeze-dried. Authenticated *Oreochromis niloticus* fish were harvested from an institutional research pond. Cleaned and sliced samples were treated with 10% of herbal extract and 10% common salt before drying. The treated fish were oven dried at 60±5°C for 14 hours. Dried fish were screened for their physical, chemical and biological quality parameters using standard protocols. Sensory attributes were evaluated using institutional sensory panel. Results revealed that dried fish prepared with herbal salt exhibited the significantly higher TPC (3.44±0.19), TAC (2.77±0.097), rehydration, fiber, protein, ash and fat contents. Also, HSDF (Herbal salted dried fish) demonstrated low microbial count, water activity and higher consumer preference for almost all organoleptic attributes. Since herbal salted dried fish possess all favorable quality characteristics and higher consumer preference, *H. indica* has potential use for value added dried fish production in cottage industries along coastal areas of Sri Lanka.

Keywords: *Halosarcia indica, herbal salt, total antioxidant capacity, Oreochromis niloticus, dried fish*

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1. Introduction

Dried fish is considered an inexpensive source of protein, essential vitamins and minerals. Therefore, it is widely used to satisfy the day to day nutritional requirements of poor people all over the world [1,2,3]. In addition, dried fish and its by-products are also used as an inexpensive nutritional source for animal feed. Since fish is a highly perishable food commodity due to microbial contamination and enzymatic processes, it requires immediate treatment to preserve its physical, chemical and biological qualities after harvesting [4,5,6]. Moreover, traditional methods such as drying, salting, pickling and smoking have been practiced as effective and safe fish preservation methods since ancient times [6]. Out of these methods, dried fish production is more popular among people due to its inexpensiveness, high consumer acceptance, unique taste, aroma and nutritional properties [7,8]. Despite this popularity, health authorities such as Food and Drug Authority (FDA) and World Health Organization (WHO) advised consumers to limit their dilatory salt intake to less than 2400 mg/day in order to prevent possible cardiovascular diseases due to high salt consumption [9,10]. Further, Sri Lanka produces 452,890 metric tons of fresh fish and exports 17,461 metric tons, which earns Rs 24,715 million, contributing 2% of GDP. Also, about 400,000 people are directly dependent on the fish industry [10]. Although, Sri Lanka has high potential for dried fish production, new innovative value added product development is stagnating due to the lack of research. Therefore, the production of low salted value-added dried fish is very timely important for the industry.

Halosarcia indica (Willd.) Paul G. Wilson (Chenopodiaceae) is a succulent, salt tolerant plant distributed in coastal areas in different parts of the world including Sri Lanka [11]. Since it contains considerable amount of salt, there is a strong possibility of using *H. indica* as a plant-based ingredient to produce value added, low salted dried fish. In the present work, attempts will be made to evaluate this natural nutrient rich, low salted alternative for dried fish production.

2. Materials and Methods

2.1. Plant Materials

Matured parts of *Halosarcia indica* plants were collected from the northern coastal area of Sri Lanka and carefully transported to the laboratory. After authentication, the herbarium specimen was prepared for fish treatment (HTS-125). The plant materials were thoroughly washed three times with distilled water and then drained for about an hour on a sieve.

2.2. Fish Samples

Authenticated *Oreochromis niloticus* fish, which was maintained at an institutional research pond, was harvested. After removing the scales, head, and innards, it was sliced horizontally following traditional dried fish preparation. Then it was washed thoroughly.

2.2.1. Extraction of Planting Materials

Cleaned, mature plant parts of *H. indica* were thoroughly washed again with distilled water three times. Then they were cut into small pieces and then ground using a grinder. Ground materials were filtered with muslin cloth and dried up to either concentrated liquid or powder form. These samples were stored in a refrigerator until use.

2.2.2. Dried Fish Preparation

Solutions of 10% herbal extract (HS) and 10% common salt solution (CS) were prepared and the previously cleaned fresh fish were dipped into these solutions for three hours. The treated fish were oven dried for 60-70°C for 14 hours (12% moisture) and prepared herbal salted dried fish (HSDF) and common salted dried fish (CSDF). These two treated dried fish samples were screened for following quality parameters with control treatment.

2.2.3. Analysis for Quality Parameters

Determination of pH, salinity, water activity, TVBN and dehydration Salinity and pH were determined using a Refractometer (ATAGO ATC-S/Mill-E, Japan) and Calomel pH meter (STARTER3000) respectively. Water activity of dried fish samples were measured by a water activity meter (Novasina ms1) at 31.3°C while sodium content was determined by an atomic absorption spectrophotometer (iCETM 3000 series Thermo Scientific, U.S.A). Determination of Total Volatile Base Nitrogen (TVN) was carried out using the procedure published by Malle, and Poumeyrol [12]. Dehydration was measured according to the procedure [13].

2.2.4. Determination of Total Microbial Count

Total Plate Count (TPC) and Yeast & Mold Count (YMC) were performed according to Sri Lankan standards (SLS 516: Part 1: 1991) and SLS 516: Part 3: 1991 microbial test method, respectively.

2.2.5. Proximate Composition

Proximate analyses (moisture, fiber, ash, fats, proteins and carbohydrate) of all the samples were determined according to AOAC (1990) standards. Specifically, the fat content was measured by soxhlet extraction. The crude protein content was determined using the Kjeldahl method. The total carbohydrate was estimated from the balance after accounting for ash, crude fiber, protein and fats.

2.2.6. Functional Properties Analysis

Samples of herbal salt powder and the herbal salted, normal salted and non-salted dried fish were powdered. The powdered samples well mixed and 3 representative samples from each category were de-fatted, mixed with 10mL of 80% methanol and then vortexed for 15 min. They were placed in a 60°C water bath for 40 min and was vortexed again repeatedly at 10 min intervals. After centrifugation at 4000 rpm for 5 min, the supernatant was decanted into a 15mL centrifuge tube and the remaining solids were re extracted with 5 mL of 80% methanol. The supernatants were pooled and stored at -20°C prior to analysis. The total phenolic content (TPC) was determined using a modified Folin-Ciocalteu method [14]. The flavonoid content (TFC) of samples was measured by the colorimetric method [15] with slight modifications. The antioxidant capacity was determined using Ferric Reducing/Antioxidant Power assay [16].

2.2.7. Sensory Evaluation

Prior to sensory evaluation, all dried fish samples were fried at temperature of 120-140°C for 5 minutes in coconut oil. Sensory parameters including smell, taste, touch and hearing for various quality attributes like appearance, flavor, aroma, texture and sound were evaluated as described in published method [17] by a twenty-five-person panel in Wayamba University of Sri Lanka.

2.2.8. Statistical Analysis

Statistical comparison of mean values was performed by General Linear Model (GLM) of ANOVA followed by Tukey Multiple Range Test using SAS (SAS Institute [18]. Data were reported as mean values and standard deviation of triplicates, including p values ($p<0.05$). Statistical analysis was conducted using MS Excel 2007 for graphical interpretations.

3. Results and Discussion

3.1. Proximate Composition

In the present study, attempts were made to exploit an underutilized succulent plant species (*Halosarcia indica*) for the extraction of herbal salt and to prepare low salted, value added dried fish for the first time in Sri Lanka. Results of the proximate composition of herbal salted dried fish (HSDF) and common salted dried fish (CSDF) are presented in Table 1. All quality parameters under the various treatment methods were compared. As shown in Table 1, proximate quality parameters of herbal salt treated dried fish exhibited relatively higher values for fat, fiber and ash contents compared to both common salted dried fish and the control. The observed higher nutritional values of HSDF might be due to the presence of herbal nutrients from *H. indica* extracts and the possible interaction of these nutrients with fish. Further, the herbal

salted dried fish content has lower moisture content, which automatically help to reduce microbial growth and eventually increase product quality.

The moisture content of CSDF and HSDF are lower than those from previous studies. This might be due to the gap between drying and moisture determination. Our results also exhibited higher fat content than those observed by Siddique et al., [19]. This might be due to sample freshness, environmental conditions and also genetic makeup of fish used.

3.2. Chemical Analysis

As indicated in Table 2, all tested parameters were significantly different (p=0.0001) between the herbal salted and common salted dried fish. Moreover, lower salinity, water activity and moisture content were observed in HSDF compared to CSDF and the control. Thus HSDF yielded favorable features, which eventually increased overall quality. Wheaton and Lawson [20], also pointed out that low water activity enhances the quality of the dried fish.

Total volatile nitrogen (TVN) is an important quality criterion for fish and fish meal. Results of the current study indicated that TVN of herbal salted dried fish is significantly higher than the common salted dried fish.

According to the Sri Lanka Standard 643: 2007 (Specification for Dried Fish), the maximum amount of salt present in dried fish is 12% (on dry basis). The salt content of herbal treated fish is less than 10%, indicating its compliance with the standard.

Table 1. Proximate composition of herbal salted dried fish (HSDF) with common salted dried fish (CSDF)

Treatment	Fiber %	Ash %	Moisture %	Fat %	Protein %	Carbs. %
CSDF (10%)	1.29±0.40	26.02±5.75	11.7±2.81	5.79±0.37	29.29±0.22	25.91±8.75
HSDF(10%)	1.52±0.09	29.85±3.01	9.85±1.91	8.31±0.40	29.85±3.02	20.84±1.29
Control	1.27±0.04	20.78±3.24	10.7±0.212	6.57±0.78	29.02±3.24	24.76±13.95

CSDF- common salted dried fish; HSDF- Herbal salted dried fish; Cars. – Carbohydrates

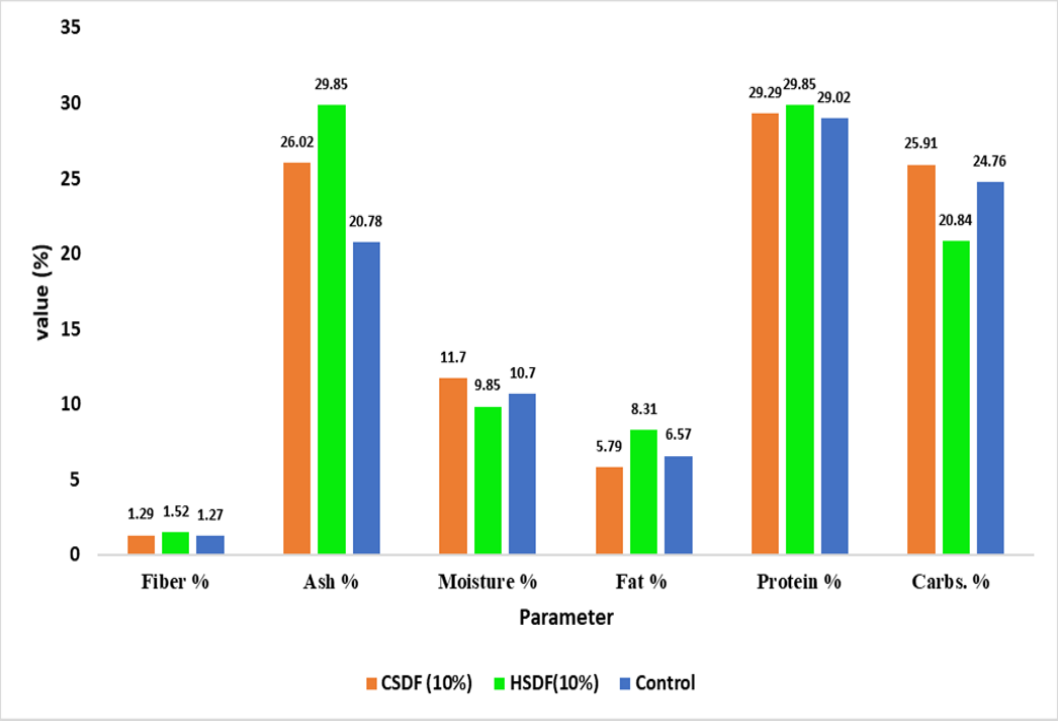

Figure 1. Comparison of salinity, water activity, moisture content and pH of herbal salted and common salted dried fish. CSDF- Common salted dried fish; HSDF- Herbal salted dried fish; TVN total volatile nitrogen content, aW- water activity

Table 2. Comparison of salinity, water activity of herbal salted and common salted dried fish

Parameter	10% HSDF	10% CSDF	Control
Salinity	17.67 ± 0.58^{e}	79.33 ± 0.58^{b}	1.67 ± 0.58^{g}
aW	0.46 ± 0.03^{ef}	0.50 ± 0.01^{d}	0.59 ± 0.05^{c}
Moisture	6.69 ± 0.54^{f}	12.73 ± 0.72^{c}	8.089 ± 0.69^{de}
pH	5.33 ± 0.27^{cd}	4.96 ± 0.37^{ef}	5.93 ± 0.47^{b}
TVN(mg/kg)	69.49 ± 2.1^{a}	57.64 ± 2.09^{b}	89.73 ± 0.00^{c}
Na ((mg/kg)	5194.22e±38.33	6006.4b±35.81	3936.32±49.73

Table 3. Aerobic plate count and yeast and mold count and rehydration values of herbal salted and normal salted dried fish

Treatment	Re-hydration data {NSD (P>0.05)}	(APC)Aerobic plate count (CFU/mL)	Yeast & Mold count(CFU/mL)
Control	1.024±0.02	29×10^4	9×10^3
CSDF(10%)	1.07±0.06	20×10^4	5×10^3
HSDF(10%)	1.038±0.00	18×10^4	4×10^3

CSDF- Normal salted dried fish; HSDF- Herbal salted dried fish.

Table 4. Total Antioxidant Capacity (TAC), Total Phenolic Content (TPC) and Total Flavonoid content (TFC) of herbal salted and normal salted dried fish

Product	TPC(mgGAE/g DW)	TAC		TFC (mgRE/g DW)
		DPPH (µM TE/gDW)	TAC(mg TE/ g DW)	
HSDF (10%)	3.44 ± 0.19^b	11.16±0.9	2.77 ± 0.10^b	0.1 ± 0.08^b
CSDF(10%)	1.6 ± 0.15^c	3.59±0.97	1.97 ± 0.03^c	Not detected
Control	1.58 ± 0.15^c	1.57±0.34	0.833 ± 0.14^d	Not detected

CSDF- Common salted dried fish; HSDF- Herbal salted dried fish

3.3. Physical and Microbial Analysis

Re-hydration, is an important quality parameter that is mainly dependent on the porosity, capillaries and cavities of dried fish surfaces. A higher re-hydration value indicates good quality [21,22]. In the present study, the re-hydration values of herbal salted dried fish significantly different (P>0.05) from common salted dried fish.

The presence of bacterial and fungal contamination can severely affect the quality and safety of dried fish [22]. The aerobic plate count (APC) & yeast and mold count of HSDF and CSDF of the different samples are presented in Table 3. Herbal salted dried fish exhibited low aerobic plate count and yeast and mold count compared to both common salted dried fish and the control. This might be due to the presence of different bioactive phenolic compounds in herbal salt. Moreover, low microbial growth is an indication of good shelf quality and safety of the product. Moreover, presence of higher microbial content of dried fish has direct relationship between moisture content presence in dried fish samples [22].

3.4. Total Antioxidant Capacity (TAC), Total Phenolic Content (TPC), and Total Flavonoid Content (TFC), of Different Dried Fish Samples

The functional properties of food stuffs are vitally important for the human health. In the present study, attempts were made to investigate the TAC, TPC and TFC of herbal salted and common salt treated dried fish samples. As demonstrated in Table 4, it is clear that herbal salted dried fish samples have significantly higher TAC, TPC and TFC compared to both CSDF and the control. This indicates that the addition of herbal salt could enhance the functional properties of dried fish. Our result is in agreement with the findings of Lorena Martinez et al. [23], who reported that the incorporation of natural plant extract will increase the functional properties and enhance the shelf quality by reducing microbial growth and water activity of the product.

3.5. Sensory Evaluation

The all tested sensory attributes such as appearance, color, flavor, texture, taste and overall acceptance of the herbal salted dried fish product were significantly ($p<0.05$) higher from normal salted dried fish (NSDF=CSDF) and the control (Figure 2). This may due the presence of marked physical, chemical and biological properties of herbal salted dried fish over the CSDF/NSDF, and the control. Quality increase of herbal treated fish samples are in agreement with previous findings [24].

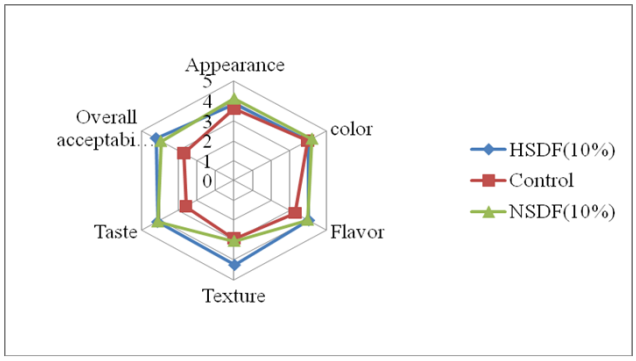

Figure 2. The effect of different treatments on Sensory attributes of herbal salted dried fish, common salted dried fish and the control. (CSDF- Common salted dried fish; HSDF- Herbal salted dried fish)

4. Conclusion

The present study described and evaluated for the first time the process of incorporation of *Halosarcia indica* plant extract for value added dried fish production in Sri Lanka. The results clearly indicated that the herbal salted dried fish has law salt content, lower water activity, low microbial content, higher TAC, TPC, TFC, re-hydration value and consumer preference compared to unsalted and common salted dried fish. Since herbal salted dried fish possess all favorable characteristics and higher consumer preference, *H. indica* plant extract could be used as important salting ingredient for value added dried fish production.

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