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Effects of Pre-treatments and Drying Methods on Chemical Composition, Microbial and Sensory Quality of Orange-Fleshed Sweet Potato Flour and Porridge

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Abstract This study was aimed to evaluate the effect of pre-treatments and drying methods on the chemical composition (proximate composition, β-carotene content and phytochemicals), functional properties, microbial and sensory of orange-fleshed sweet potato flour and porridge. Physical (blanching) and chemical (1% salt, 0.5% citric acid solution soaked for 20 min) of the sliced OFSP followed by drying (sun, solar and fluidized bed dried) with complete randomized design for chemical composition, functional properties, and microbial load analysis and randomized complete block design was used for sensory analysis. The moisture (4 - 8%), protein (4 - 8%), fat (0.9 - 2.5), ash (4 - 8%), fiber (3.5 - 7%), total carbohydrates (80 - 84%) measured as a function of treatment and drying. The energy contribution of OFSP was determined by difference of the proximate excluding the fiber (352.9-365.6kcal/100g). The salt treated and FB dried had significantly lowest moisture content and highest ash content, citric acid treated and FB dried had significantly highest protein content and gross energy, control and FB dried had significantly highest fiber content, control and sun dried had significantly highest fat content and blanched and FB dried had significantly highest total carbohydrates. The β-carotene (82 -127μg/g), tannin (74 -108mg/100g) and phytate content (51 - 98mg/100g) was measured. Blanched and FB dried was observed better in retention of β-carotene and reduction of phytochemicals (tannin and phytate). The salt treated and FB dried was measured increment with WAC, viscosity and lowest LGC, blanched and FB had highest OAC and high bulk density in the control. The microbial analysis showed OFSP porridge within microbiological acceptable limit. The sensory acceptability showed OFSP was accepted in all sensory attributes. In conclusion, the blanching and FB drying techniques were the best approach in retaining the nutrients.

Keywords: *β-carotene, chemical composition, drying method, orange-fleshed sweet potato, pre-treatment, microbial quality, sensory acceptability*

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1. Introduction

Sweet potato (*Ipomoea batatas*L.) ranks seventh among the most important food crops in the world [43]. Sweet potatoes are a good source of minerals [22], carbohydrates, fiber, antioxidants, starch and vitamins [4,28]. Orange-fleshed sweet potato (OFSP) is rich in beta-carotene, which is a precursor to vitamin A Contributes in alleviating vitamin A deficiency. Vitamin A deficiency is a major public health problem in developing countries of the most vulnerable groups [21]. The short shelf life of sweet potato due to its pershiblity of sweet potato [41] is a challenge in developing countries [46]. In Ethiopia sweet potato cultivation is currently being encouraged because of its numerous potential for food security; even though most of the Ethiopian farmers have the challenge of sweet potato tuberous roots storage after harvest like other parts of developing countries [41].

Drying methods are commercially accepted and economic of the raw and intermediate potato products to preserve by reducing the bulk weight [10,42,52]. Blanching, soaking in solution inactivate the enzyme activities (quality reduction and deterioration reduced), and improve product acceptability [9,12]. The futures of Orange-fleshed sweet potato in the developing country for target consumers with micronutrient supplemented porridge, bread, traditional doughnut, chapatti and cake is promising [31]. OFSP is a source of energy and nutrients, natural sweetener, color, flavor and dietary fiber [48].

2. Materials and Methods

The deep orange colored Tula variety (Voucher number CIP420027) orange-fleshed sweet potato was used to evaluate the nutritional and functional properties, microbial and sensor quality of OFSP flour and porridge. The tuber was Blanched in a water bath at 60°C for 5 min according to the method described by Emmanuel [13], soaked in salt solution of 1% concentration and citric acid solution (0.5%) for 20 min based on the method described by Bechoff [10] with slight modification and dried(sun, solar and fluidized bed drier at 65°C), Figure 1. The dried OFSP was milled in to flour and analyzed nutritional profile, functional properties, microbial and sensory quality using a standard method. Sensory analysis was conducted for the porridge (10gm Orange-fleshed sweet potato flour, 200ml water, about 1g salt and 3g sugar cooked for 8 min according to USAID [45].

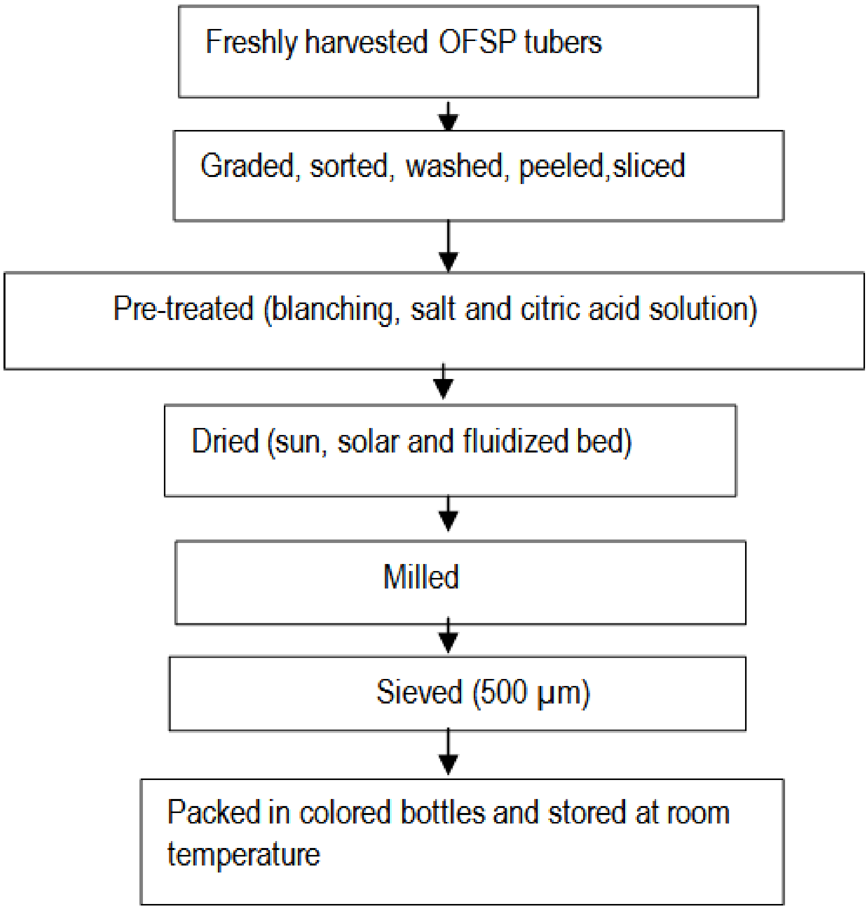

Figure 1. Flow chart for OFSP flour preparation; Source: [13]

The nutritional profile; Proximate composition [15,16], β-carotene [36], pH-value [15,16], water and oil absorption capacity [8], bulk density [8], least gelation capacity [2], phytochemicals such as tannins and phytate content were determined according to Maxson and Rooney [24] and Latta and Eskin [20]; respectively. The total plate count, yeasts and mold count analysis was conducted for the porridge [29]. The sensory quality of porridge was studied using the nine hedonic points.

The experiment was consisted of two factors three pre-treatments and three drying methods. Untreated OFSP sample was taken as a control. The experimental design was completely randomized design (CRD) for chemical composition, functional properties and microbial load and Randomized Complete Block Design (RCBD) for the sensory analysis. The data was subjected to two factor-analysis of variance (ANOVA) used SAS (Statistical Analysis System, version 9.1; SAS Institute, 2001). All the samples were analyzed in duplicates and results were expressed as mean ± standard deviation. The Fisher's least significant difference (LSD) test was used to test differences between means and the significant was set at ($P<0.05$).

3. Results and Discussions

3.1. Proximate Composition

The proximate composition (crude fat, crude protein, crude fiber, carbohydrate, ash, moisture) was analyzed and a significant difference was observed on the OFSP flour as affected by pre-treatments and drying methods (Table 1). The moisture content of OFSP flour was measured between 4 to 8%. The lower moisture contents the better shelf life and denser nutrient composition [19,26,51]. The salt treated in fluidized bed dried product revealed lowest moisture content. This is due to the fact that salt brining causes in the dehydration of the OFSP tuber and the high temperature of fluidized bed applied at a moderately short time compared to solar and sun dryer. Protein content was measured between 4 to 6%. The citric acid treatment with all drying method, salt and control with fluidized bed dried was observed increment in the crude protein content. The blanched sundried was observed reduced crude protein content due to the protein denaturation, leaching out and prolonged drying in uncontrolled environment [14,23,26,27,30,38]. Ünlüsayin et al. [44] describes salt induces the change in protein structure and denaturation up to 20-25%. The controlled and blanched fluidized bed dried was observed increment in its fiber content. The fat content (0.9 to 2.55%); Control sun dried measured increased fat content while the blanched with all drying methods was decreased fat content decrement. Different studies showed sun dried root and tuber crops had high fat than other drying methods [3,16,23,27]. The reduced fat content of the blanched OFSP was due to oxidation at increased temperature. Ash is important food constituent and inorganic residue after combustion at high temperature - prolonged time [18]. The ash content was measured between 4-7.5%. Salt treated fluidized bed dried and solar dried detected high due to salt absorption during soaking and lower moisture content [26] and blanched sun dried flour were measured with lowest ash content due the sensitivity of specific minerals to temperature at prolonged time during blanching and drying [3,16,23].

Table 1. The Proximate Composition of OFSP flour

Sample	Moisture (%)	Protein (%)	Fiber (%)	Fat (%)	Ash (%)	Carbohydrate (%)
Control - Sun dried	7.36±0.08^{b}	4.39±0.05^{f}	4.12±0.26^{def}	2.55±0.06^{a}	5.14±0.06^{ef}	80.62±0.05^{f}
Control - Solar dried	6.35±0.02^{e}	4.63±0.00^{e}	5.59±0.02^{b}	2.04±0.08^{b}	5.43±0.06^{de}	81.56±0.03^{e}
Control - Fluidized bed dried	5.11±0.06^{g}	5.06±0.15^{d}	7.30±0.43^{a}	1.48±0.01^{e}	5.68±0.10^{cd}	82.68±0.10^{c}
Blanched - Sun dried	7.79±0.06^{a}	4.10±0.07^{g}	3.84±0.09^{fg}	1.17±0.06^{h}	4.15±0.07^{h}	82.79±0.15^{c}
Blanched - Solar dried	6.46±0.04^{e}	4.21±0.05^{g}	5.30±0.06^{bc}	0.99±0.01^{i}	4.67±0.06^{g}	83.69±0.07^{b}
Blanched - fluidized bed dried	5.46±0.03^{f}	4.34±0.03^{f}	7.07±0.07^{a}	0.90±0.01^{i}	5.10±0.14^{f}	84.20±0.16^{a}
Salt -Sun dried	6.78±0.12^{d}	4.45±0.05^{f}	4.63±0.07^{de}	1.42±0.01^{e}	6.78±0.40^{b}	80.01±0.58^{f}
Salt -solar dried	5.09±0.05^{g}	4.73±0.03^{e}	4.17±0.29^{efg}	1.32±0.00^{fg}	7.31±0.08^{a}	81.56±0.06^{e}
Salt - fluidized bed dried	4.04±0.05^{i}	5.18±0.08^{d}	4.45±0.19^{cd}	1.26±0.00^{g}	7.51±0.11^{a}	82.01±0.15^{d}
Citric acid-sun dried	7.13±0.04^{c}	5.44±0.03^{c}	3.73±0.04^{g}	1.89±0.06^{c}	5.25±0.01^{ef}	80.30±0.05^{f}
Citric acid – solar dried	5.40±0.09^{f}	5.61±0.01^{b}	4.32±0.26^{def}	1.62±0.05^{d}	5.59±0.04^{d}	81.78±0.08^{de}
Citric acid-fluidized bed dried	4.38±0.02^{h}	5.76±0.01^{a}	4.78±0.49^{de}	1.40±0.04^{ef}	5.96±0.02^{c}	82.50±0.01^{c}

a-g All values are means±SD

All values within the same column with different superscript letters are significantly different from each other at ($p<0.05$).

3.2. Beta Carotene Content

The β-carotene content was measure between 82 to 127μg/g as shown below (Figure 2). Blanching with fluidized drying measured higher β-carotene content as the enzyme (peroxidases, and lipoxygenases) activities which have a capacity in degrading β-carotene [35] was inactivated and β-carotene degradation was delayed. Salt and citric acid treated OFSP flour shows no significant difference but increment was observed relative to the control. Salting reduces osmotic tension of cells increasing the stress on bacteria and enzymes [47].

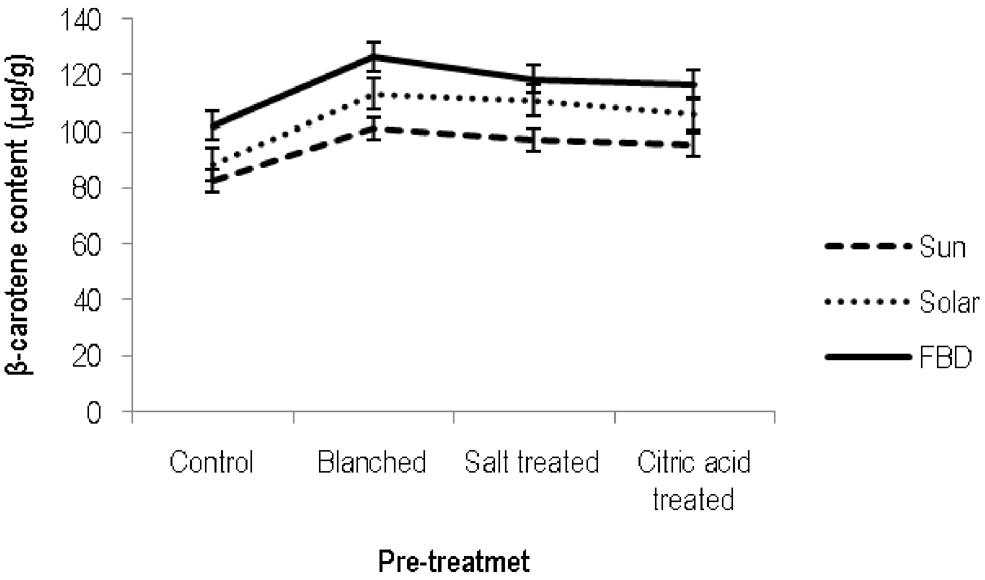

Figure 2. The beta-carotene content (μg/g) of OFSP flow as affected by pre-treatment and drying

A combination of blanching and fluidized bed drying techniques had higher retention on the beta-carotene content of OFSP flour samples compared to the other. Pre-treatments and drying methods had significant effect on the beta-carotene content of OFSP flour.

3.3. Phytochemical Composition and pH Value

Tannin and phytate of OFSP flour was detected between 74 to 108 and 51 to 98/100g respectively. Control sun dried OFSP flour was measured high in tannin content while the blanched and fluidized bed dried OFSP flour shows lowest in tannin and phytate content. Pre-treatments reduce levels of both tannin and phytate content in different dried products [25,34,49]. The decrease in tannin and phytate content in fluidized bed dried OFSP might have due to more controlled conditions of temperature and air velocity and also with the fluidized nature of drying particles. Pareek and Kaushik [32] reported highest tannin content was recorded in solar dried aonla flour followed by oven dried, microwave dried and lowest in fluidized bed. The pH value was measured between 4.5 to 7.0 for all pre-treatments and drying methods. The citric acid treated and sun dried OFSP flour was observed lower pH level. The higher acidity value was due to the added citric acid in the solution or the acidifying property of citric acid.

Table 2. effect of pre-treatments and drying methods on the phytochemicals and pH value of OFSP flour (mg/100g)

Sample	Tannins	Phytate	pH
Control - Sun dried	108.46±1.33^{a}	98.39±1.57^{a}	5.53±0.03^{f}
Control - Solar dried	97.16±0.12^{c}	94.27±0.40^{b}	5.69±0.01^{e}
Control - Fluidized Bed dried	92.49±0.62^{d}	80.61±0.54^{c}	5.73±0.07^{de}
Blanched -Sun dried	90.75±0.13^{e}	61.78±0.22^{g}	5.59±0.02^{f}
Blanched - Solar Dried	82.89±1.29^{g}	59.21±0.21^{h}	5.71±0.07d^{e}
Blanched - Fluidized Bed dried	74.15±0.83^{h}	50.78±0.22^{j}	5.79±0.06^{d}
Salt - Sun dried	98.11±0.04^{c}	66.28±0.94^{de}	6.48±0.01^{c}
Salt - Solar dried	92.88±0.13^{d}	64.19±0.35^{f}	6.63±0.02^{b}
Salt - Fluidized Bed dried	86.33±0.67^{f}	56.73±0.64^{i}	6.71±0.02^{a}
Citric acid - Sun dried	100.05±0.62^{b}	66.78±1.65^{d}	4.63±0.02^{h}
Citric acid - Solar dried	96.72±0.04^{c}	64.74±0.85^{ef}	4.74±0.03^{g}
Citric acid- Fluidized Bed dried	91.78±0.12^{de}	57.23±0.07^{i}	4.78±0.01^{g}

$^{a-h}$All values are means±SD

All values within the same column with different superscript letters are significantly different from each other at ($p<0.05$)

3.4. Functional Properties

Pre-treatments and drying have a significant effect on the bulk density, water absorption capacity, oil absorption capacity, viscosity of OFSP flour. Bulk density is important for the selection of packaging material [18] was measured between 0.70 to 0.75g/ml. The control fluidized bed dried OFSP flour was measured higher bulk density. However, the pre-treatments have no significant effect [2,11]. Olapade and Ogunade [30] observed higher bulk density in the blanched cabinet dried yellow and cream fleshed sweet potato flour. Therefore, different bulk density was observed different for different root and tuber crops due to the difference of variety, pre-treatment, blanching time and temperature and drying method used. The water absorption capacity of OFSP flour was measured 2.81 to 3.9ml/g. The salt treated fluidized bed dried OFSP flour were measured higher due to high polar amino acid residue of protein having affinity for water [50] while blanched sun dried flour had lowest water absorption capacity. The oil absorption capacity of OFSP flour was measured from 0.55 to 1.03ml/g. The Sun dried flour had lowest oil absorption capacity compared to solar and fluidized bed dried in all pre-treatments and the blanched - fluidized bed dried OFSP flour was observed with high oil absorption capacity. Viscosity is the ability of starch to form paste after cooling and the unstable starch accompanied break down the bonding and damaged starches [1,39]. The viscosity of OFSP flour was measured between 72 to 371.2cps. The salt treated fluidized bed dried OFSP flour and porridge had measured high highest viscosity value. The higher viscosity value was due to the lowest moisture content and higher water absorption capacity of the fluidized bed dried flour and form a thick porridge with desirable attribute for industrial uses as a thickening power is required [7]. The least gelation capacity of OFSP flour samples ranged from 7.0 to 20.5% (Table 3). Citric acid treatment and Sun drying was observed with increased gelatin capacity in treatments. Salt and fluidized bed drier and their combination showed that lowest gelation property as shown in below (Table 3).

Table 3. The Functional properties of OFSP as affected by pre-treatments and drying process

Sample	BD(g/ml)	WAC(ml/g)	OAC(ml/g)	Viscosity(cps)	LGC (%)
Control - Sun dried	0.71±0.00^{d}	2.90±0.00^{ef}	0.55±0.01^{h}	79.4±0.28^{k}	18.80±0.28^{b}
Control - Solar dried	0.72±0.00^{b}	3.14±0.01^{d}	0.63±0.02^{fg}	144.5±0.71^{g}	17.45±0.07^{c}
Control - Fluidized Bed dried	0.74±0.00^{a}	3.43±0.04^{c}	0.75±0.01^{cd}	290.7±0.85^{c}	11.10±0.14^{g}
Blanched -Sun dried	0.71±0.00^{d}	2.81±0.15^{f}	0.71±0.00^{de}	95.55±0.49^{j}	17.65±0.35^{c}
Blanched - Solar Dried	0.71±0.00^{cd}	3.06±0.04^{de}	0.89±0.00^{b}	155.0±1.41^{f}	16.3±0.14^{d}
Blanched - Fluidized Bed dried	0.73±0.00^{ab}	3.38±0.01^{c}	1.03±0.06^{a}	311.70±1.13^{b}	9.4±0.28^{h}
Salt - Sun dried	0.71±0.00^{cd}	3.42±0.06^{c}	0.66±0.04^{efg}	119.50±0.71^{i}	16.05±0.07^{d}
Salt - Solar dried	0.72±0.00^{c}	3.68±0.08^{b}	0.74±0.00^{cd}	242.85±0.92^{e}	14.0±0.71^{e}
Salt - Fluidized Bed dried	0.73±0.00^{ab}	3.9±0.04^{a}	0.94±0.06^{b}	371.15±0.92^{a}	7.0±0.28^{i}
Citric acid - Sun dried	0.71±0.00^{d}	3.18±0.11^{d}	0.6±0.04^{gh}	72.65±0.49^{l}	20.5±0.71^{a}
Citric acid - Solar dried	0.71±0.00^{cd}	3.41±0.15^{c}	0.71±0.02^{def}	134.0±1.41^{h}	18.65±0.07^{b}
Citric acid- Fluidized Bed dried	0.73±0.00^{ab}	3.78±0.01^{ab}	0.81±0.01^{c}	267.0±0.99^{d}	12.35±0.21^{f}

$^{a-i}$All values are Means±SD

All values within the same column with different superscript letters are significantly different from each other at ($p<0.05$)

BD= Bulk density, WAC= Water absorption capacity, OAC= Oil absorption capacity, LGC=Least gelation capacity.

3.5. Microbial Quality

The porridge of OFSP was analyzed for the microbial quality to guarantee the quality at the time of consumption after two months storage. Total plate count (TPC), yeast and mold was detected (1.53-2.88*10^2 and 0.43-1.35*10^2cfu/ml; respectively) for the pr-treated and dried OFSP porridge. The salt treated OFSP porridge had lowest TPC and the control had highest as the salt solution inhibits the microbial growth at the time of raw material preparation [33]. The citric acid treatment dried with fluidized bed drier shows lowest yeast and mold and TPC count. The microbial dose was observed in the acceptable limits as International microbiological standards recommended units for foods total bacterial plate counts should be less than 10^3cfu/g and the International Commission for Microbiological Specification for Foods [17] states that ready-to-eat foods with plate counts between 0-10^3 are acceptable, between 10^4 - ≤ 10^5 is tolerable and 10^6.

Table 4. Microbial load (10^2cfu/ml) of OFSP flour as affected by pre-treatment and drying process

Sample	Total plate count	Yeast and Mold count
Control - Sun dried	2.88±0.04^{a}	1.35±0.71^{a}
Control - Solar dried	2.78±0.04^{ab}	1.00±0.73^{c}
Control - Fluidized Bed dried	2.58±0.04^{cde}	0.85±0.85^{de}
Blanched -Sun dried	2.73±0.04^{abc}	1.15±0.95^{b}
Blanched - Solar Dried	2.58±0.04^{cde}	0.88±1.06^{cde}
Blanched - Fluidized Bed dried	2.43±0.18^{e}	0.65±1.41^{fg}
Salt - Sun dried	2.53±0.04^{de}	0.98±0.35^{cd}
Salt - Solar dried	2.18±0.04^{f}	0.75±0.65^{ef}
Salt - Fluidized Bed dried	1.53±0.04^{h}	0.58±0.35^{g}
Citric acid - Sun dried	2.63±0.04^{bcd}	0.75±0.71^{ef}
Citric acid - Solar dried	2.43±0.18^{e}	0.58±0.35^{g}
Citric acid- Fluidized Bed dried	1.98±0.04^{g}	0.43±0.35^{h}

$^{a-g}$All values are means±SD

All values within the same column with different superscript letters are significantly different from each other at (p<0.05).

3.6. Drying Effect on Product Quality

The OFSP raw tuber was dried; (Sun, solar and fluidized bed) after cleaning, sorting and sliced in to uniform pieces to maintain uniform drying process. After drying the dried OFSP was grounded into flour and then the moisture content was measured. The lower the moisture content the better shelf life and nutritional profile. The moisture content of OFSP flour was measured below 8% for all drying techniques. FBD was observed lower moisture content as a result better nutrient density and lower phytochemical (phytate and taninins) composition as shown in Table 1 and Table 2; respectively. The FBD was better in β-carotene retention and functional properties comparedto solar and sun drying (Figure 2 and Table 3). This is due to the fact that the β-carotene degrading enzymes and the volatile components of OFSP were delayed in a controlled manner [35]. Drying has a significant effect on the total microbial load of the OFSP porridge (Table 4). Porridge prepared from the fluidized bed dried orange fleshed sweet potato powder was better in its total microbial quality due to the saving in the cross contamination and control in growth of microorganisms. Drying shows insignificant effect on the sensorial quality attributes of porridge. However, product made from sun dried was liked by the consumers. This might be due to adaptation of the traditional products prepared by sun drying process.

3.7. Sensory Quality

Consumer based sensory quality of porridge was conducted using the nine-hedonic point of the porridge's color, taste, aroma, mouth feel and overall acceptability as it affects the purchasing behavior of consumers [40] Table 5. All the sensory attributes were liked slightly - moderately. The color of blanched with sun and solar dried were liked more due to the inactivation of endogenous enzymes reduce pigment (yellowish and brown color) degradation. Citric acid treated with fluidized dried porridge was liked more for its taste and no significant difference was observed for aroma. The citric acid treated sun dried; salt treated fluidized bed dried and blanched fluidized bed dried were score high for the mouth feel of OFSP porridge. The mouth feel depends on moisture content, viscosity, bulk density and taste difference. Blanched sun dried and citric acid treated sun dried was scored higher value for the overall acceptability. The study revealed sensory qualities were affected by pre-treatments and drying methods.

Table 5. Sensory acceptability score of OFSP porridge as affected by pre-treatments and drying methods

Sample	Color	Taste	Aroma	Mouth feel	Overall acceptability
Control - Sun dried	7.09±1.21^{abcd}	6.31±1.48^{f}	6.11±1.47^{b}	5.83±1.44^{d}	6.70±1.04^{cd}
Control - Solar dried	7.15±1.34^{abcd}	7.13±1.26^{ab}	6.18±1.62^{b}	5.75±1.31^{d}	6.48±1.15^{d}
Control - Fluidized Bed dried	6.95±1.77^{cd}	7.08±1.63^{abc}	6.18±1.68^{b}	6.23±1.61^{c}	6.58±1.42^{cd}
Blanched -Sun dried	7.49±1.58^{a}	7.03±1.36^{abc}	6.74±1.68^{a}	6.05±1.45^{c}	7.20±1.12^{a}
Blanched - Solar Dried	7.48±1.97^{a}	6.60±1.77^{def}	6.53±1.54^{ab}	6.30±1.63^{bc}	6.78±1.32^{bcd}
Blanched - Fluidized Bed dried	7.35±1.20^{abc}	6.68±1.29^{cdef}	6.78±0.81^{a}	6.76±1.18^{a}	6.90±0.95^{abc}
Salt - Sun dried	7.03±0.94^{bcd}	6.98±1.14^{abcd}	6.85±0.97^{a}	6.58±0.74^{abc}	7.05±0.78^{ab}
Salt - Solar dried	6.93±1.22^{d}	6.80±0.93^{bcde}	6.83±1.10^{a}	6.58±0.78^{abc}	6.88±0.72^{abc}
Salt - Fluidized Bed dried	6.85±0.92^{d}	7.08±1.38^{abc}	6.70±1.13^{a}	6.83±1.19^{a}	6.90±0.87^{abc}
Citric acid - Sun dried	7.25±0.95^{abcd}	7.25±1.12^{a}	6.83±1.14^{a}	6.89±1.11^{a}	7.05±0.78^{ab}
Citric acid - Solar dried	7.38±1.49^{ab}	7.03±1.20^{abc}	6.63±1.42^{a}	6.58±1.29^{abc}	6.80±1.26^{bcd}
Citric acid- Fluidized Bed dried	6.35±1.24^{e}	6.43±1.12^{ef}	6.65±1.16^{a}	6.33±1.09^{bc}	6.53±0.98^{d}

$^{a-f}$All values are means±SD

All values within the same column with different superscript letters are significantly different from each other at (p<0.05).

4. Conclusions

The orange-fleshed sweet potato flour was prepared by pre-treating of the OFSP tuber with 0.5% citric acid, 1% salt solution and blanching. The pre-treated and control OFSP were dried with sun, solar and fluidized bed drying methods. In the conversion of OFSP to flour the pre-treatments and drying methods and their combination had a significant effect on the chemical composition, functional, microbial and sensory quality of OFSP flour and porridge. Blanching and fluidized bed drying method had a significant effect on the nutrient retention and a best

Combination processing method of OFSP flour and porridge is the best approach for preparing OFSP flour and porridge, enriched with pro-vitamin A. OFSP is rich is β-carotene (pro-vitamin A) recommended to supplement stable food lucked with vitamin A and vitamin A deficiency reduction will be granted. The porridge prepared from OFSP flour was slightly too moderately acceptable to all sensory attributes and within the acceptable microbial limit according to the International Commission for Microbiological Specification for Foods. The post-harvest loss (physiological and nutritional losses) of OFSP is manageable with the cost-effective pre-treatment and controlled drying (fluidized bed drying) methods use.

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