



Effect of Salting on Mechanical Drying of *Pangasius hypophthalmus*

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ABSTRACT

A study was conducted during 2016 to evaluate the effect of salt and mechanical drying on *Pangasius* at Central Institute of Fisheries Education, Andheri, Mumbai, India. In this study, the salted and unsalted *Pangasius* was mechanically dried at 60°C temperature and the quality of the dried *Pangasius* was evaluated. The quality parameters include the changes in proximate composition, physicochemical parameters [total volatile base nitrogen (TVBN), peroxide value (PV), free fatty acid (FFA), pH, thiobarbituric acid reactive substances (TBARS), salt, water activity], microbial enumeration (total viable count (TVC), *Escherichia coli*, *Staphylococcus* spp.) and sensory evaluation. The colour characteristics, percentage yield and storage stability of the product was also evaluated. From the results, it was observed that the protein and ash content of unsalted dried *Pangasius* was higher than salt dried *Pangasius*. From the results of physicochemical changes, it was observed that PV, FFA, TVBN, TBARS and salt content were higher in salt dried *Pangasius*. The TVBN, PV and salt content of salt dried *Pangasius* were 24.75 mg N 100 g⁻¹, 4.17 meq O₂ kg⁻¹ fat and 14.55% respectively which were higher than the Unsalted dried *Pangasius*. The salt dried *Pangasius* had higher *L*^{*} value but lower *a*^{*} and *b*^{*} value than unsalted dried *Pangasius*. The unsalted dried *Pangasius* was unstable during storage whereas salt dried *Pangasius* was stable. Based on the results, it was concluded that salt drying is the most effective method of preservation for drying *Pangasius* at 60°C.

KEYWORDS: Colour, drying, pangasius, proximate, physico-chemical, quality, salting, sensory

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1. INTRODUCTION

In India, the culture of *Pangasius hypophthalmus* was initially practised in small scale in West Bengal and later its culture shifted to large scale in Andhra Pradesh. Presently, *P. hypophthalmus* is cultured in Kerala, Tamilnadu, Maharashtra, Andhra Pradesh, West Bengal, Orissa, Karnataka and Uttar Pradesh. According to Anonymus (2018), the production of Culture Fisheries in India during the year 2017–18 was 705600 MT of which Pangasius production was 26,293 MT with Andhra Pradesh as leading producer (24,845 t) followed by Maharashtra (573 t). The total production and area of cultivation of Pangasius were 26,293 t and 3,863 ha.

Fish is a good source of animal protein contains all essential aminoacids that are required for the growth and development of body and has low fat content (Richa et al., 2021; Begum et al., 2011 and Begum et al., 2012). Fish consumption can help in brain and nervous system development during foetal and infant stages of life as fish is a good source of vitamins (D and B2), minerals, high protein content, essential amino acids, omega 3 fatty acids that are required for enhancing nutrition and living a robust life (Anonymus, 2016a, Kumar et al., 2020; Kim et al., 2020; Richa et al., 2021).

Fish is a considered as a perishable commodity due to its high susceptibility to spoilage as it contain high moisture as it favours the growth of microorganisms leading to spoilage of fish within 24 hours if it's not used (Huss et al., 1974; Kumar et al., 2020; Begum et al., 2012 and Richa et al., 2021). Due to lack of proper preservation and storage facilities a lot of fish is being lost. Hence preserving the fish immediately after harvest can reduce the loss fish post-harvest (Elhesain et al., 2021).

Curing is a traditional method of preservation commonly used in the developing and under-developed countries and the cheapest method of preservation as expensive technologies are not required. Curing preserves the fish by rendering the medium an unsuitable environment for microbial propagation. Principle means of accomplishing preservation by curing is done by increasing the concentration of soluble substances in the medium either by removing water or by causing soluble substances (salt, sugar) to diffuse into the medium. Fish curing consists of preservation techniques like drying, smoking, salting, pickling or a combination of these techniques and miscellaneous methods that are in use like fermentation process or ripening and use of vinegar in marination (Jarvis, 1988).

Drying is a traditional method of preservation of fish converting wet products into the dry state with the benefit of preventing microbial growth and spoilage, offering ease of handling due to a reduction in bulk and reducing handling

costs (Dev and Raghavan, 2012; Hu et al., 2013). Simple sun drying was widely practised traditional method where preservation is achieved by lowering the water content of fish and creating an unsuitable environment for the activity of microorganisms. Dried and dehydrated foods are more concentrated than any other form of foodstuff. Traditionally, fish products were immersed in concentrated solutions of salt and/or other curing ingredients which impregnate into fish and prolong the shelf life of fish (Valencia-Pérez et al., 2008; Vega-Galvez et al., 2011). Some authors reported that salt pretreatment before drying has yielded a good quality dried product (Taiwo et al., 2003) and also reduced the drying time (Fito and Chiralt, 2003; Rastogi et al., 2002). Salting pretreatment combined with hot air drying presents a promising combination of hurdle technologies leading to a stable fish product (Fito and Chiralt, 2003). Based on this background, a study was conducted to evaluate the effect of salt on mechanically dried Pangasius.

2. MATERIALS AND METHODS

2.1. Raw material and processing

The experiment was carried out during the month of November, 2016. 50 kg of Pangasius was purchased from Khar land Research Station in Panvel, Mumbai, India, immediately iced and brought to the laboratory within 4 hours. The length and weight of Pangasius varied from 38–45 cm and 900–1300 grams respectively. Upon arrival to the laboratory, the fish were washed with chilled water to remove dirt and slime, beheaded, eviscerated and split opened in butterfly style. The butterfly style cut fish were washed thoroughly with chilled water to remove adhering blood and viscera.

The butterfly style cut Pangasius was used for drying. Pangasius was divided into two lots. One lot was used for the production of unsalted mechanically dried Pangasius and the second lot was used for producing salted and mechanically dried Pangasius. For salt drying, fish was dry salted at 1:3 ratio (salt: fish) at room temperature (32°C) for 48 hours before drying. After 48 hours the fish was taken out and excessive salt on the surface was rubbed off. The unsalted and salted Pangasius were dried in an accelerated mechanical dryer (Yarrow and Co. Ltd., Glasgow, Scotland) at a controlled temperature of 60°C±5°C with an air velocity of 2.0±0.3 m/s maintained in each test till the required moisture content was attained (below 20%).

2.2. Sampling

The sampling was carried out by taking 4 fish (3 for biochemical and microbial analysis and 1 for sensory evaluation) of unsalted mechanically dried and salted mechanically dried Pangasius respectively. Initially, samples were collected for microbiological analysis in a sterile

environment and the rest of the samples muscle portion was mixed, weighed, macerated in pestle and mortar and was used for analyses.

2.3. Proximate composition

Moisture, fat, protein and ash content were determined according to Anonymus (2005). Differences in weight were recorded after drying the sample in a hot air oven at $100 \pm 5^\circ\text{C}$ overnight to determine the moisture content. The crude protein content was measured following the micro-Kjeldahl method using Kjelplus equipment (Pelican instruments, Chennai, India). Ashing was done by incineration of the sample in a muffle furnace (CEM Corporation, USA) at $550 \pm 50^\circ\text{C}$ until white ash was obtained. Total lipid was estimated by the Soxhlet extraction method with diethyl ether.

2.4. Biochemical quality parameters

For pH measurement, ten grams of fish muscle was homogenized in 50 ml distilled water in a homogenizer (Polytron system PT 2100, Kinematica, AG, Germany) for 30s and the pH was measured using the digital pH meter (Eutech tutor pH/ $^\circ\text{C}$ meter, Eutech Instruments, Singapore). TVB-N was determined based on an adaptation of the current official European steam distillation method with slight modifications using Trichloroacetic acid as described by Vyncke (1996). Peroxide value (PV) was determined according to the method of Jacob (1958) and was expressed as meq of O_2 kg^{-1} of fat. The free fatty acids (FFA) were determined from the chloroform extracts of muscles ground with anhydrous sodium sulphate according to Anonymus (2005). Thiobarbituric acid reactive substances (TBARS) was estimated by the method of Tarladgis *et al.* (1960). The salt content was evaluated by Mohr's method as described in Kenkel (1994) and expressed as percentage NaCl. Water activity was measured by using Durotherm a_w meter.

2.5. Microbiological quality parameters

The microbiological parameters such as Total Viable Count (TVC) and *Escherichia coli* were enumerated as per Anonymous (2001). A 10 g portion of the sample was aseptically weighed and transferred to a sterile stomacher bag and 90 ml of sterile physiological saline (0.85% w/v NaCl) was added and the mixture was homogenized using a stomacher (Lab Blender 400, Seward Medical, UK). For the enumeration of the total viable count, 0.1 ml of the serial dilution of homogenate was spread on Plate count agar (Himedia, India) and incubated at 37°C for two days. Enumeration of *Escherichia coli* was done by MPN method with initial inoculation of the sample at different volumes by a 3-tube method in Lauryl tryptose broth (Lauryl sulphate broth) (Himedia, India) for coliforms for 24 hours and then positive tubes were re-inoculated in EC broth with 24 hours

incubation at 37°C . *Staphylococcus* spp. was enumerated by Spreading 1 ml of inoculum equally to 3 plates of Baird-Parker agar (0.4, 0.3, 0.3 ml) using a sterile glass rod which was incubated for 48 hours at 37°C . The colonies containing circular, smooth, convex, moist, 2-3 mm in diameter, grey to jet-black, frequently with light-coloured (off-white) margin, surrounded by opaque zone and frequently with an outer clear zone. The total fungal count was enumerated by spreading inoculum on Rose Bengal chloramphenicol agar plates and incubating the plates at $28 \pm 1^\circ\text{C}$ for 3-5 days.

2.6. Sensory evaluation

For sensory evaluation, the dried Pangasius was cooked in water at 100°C for 20 min separately and brought to room temperature. The sensory evaluation for overall acceptability of the dried fish was done by 10 trained panellists using 9 point hedonic scales viz., Like extremely (9), Like very much (8), Like moderately (7), Like slightly (6), Neither like nor dislike (5), Dislike slightly (4), Dislike moderately (3), Dislike very much (2), Dislike extremely (1).

2.7. Yield

The yield of drying was calculated from the difference in weight of dressed Pangasius, unsalted or salted Pangasius and dried Pangasius.

2.8. Storage stability studies

To examine the storage stability of dried Pangasius by different methods, 500 grams of salted and unsalted mechanically dried Pangasius was packed in 12 μ PET/80 μ PE pouch and kept at room temperature for 2 months to check the stability of product based on physical observations only to check the consistency of product like colour, odour, texture and foreign matter.

2.9. Statistical analysis

All analyses were carried out in triplicates and subjected to tests. To estimate the significant difference within the treatments analysis of variance was performed by one-way ANOVA procedures with the application of Duncan's multiple range tests and descriptive statistics using SPSS 16 (SPSS Inc., Chicago, IL, USA). The least significant difference (LSD) was used to test for the difference between means and significance was defined at $p < 0.05$. Results were reported as mean values of determinations \pm Standard Deviation.

3. RESULTS AND DISCUSSION

3.1. Proximate composition

The fresh Pangasius consisted of moisture $78.14 \pm 0.45\%$, protein $18.23 \pm 0.04\%$, fat $2.29 \pm 0.36\%$ and ash $1.44 \pm 0.85\%$. The moisture content of unsalted and salted mechanically dried Pangasius at 60°C was recorded as 13.41 and 13.56% respectively (Table 1). The decrease in moisture content

Table 1: Changes in proximate composition (%) of mechanically dried Pangasius at 60°C

Drying conditions	Moisture	Protein (%)	Fat (%)	Ash (%)
Fresh fish	78.14±0.45 ^b	18.23±0.04 ^a	2.29±0.36 ^a	1.44±0.85 ^a
T ₁	13.41±0.12 ^a	67.75±0.71 ^c	11.81±1.14 ^c	4.26±0.32 ^b
T ₂	13.56±0.49 ^a	60.50±0.25 ^b	8.26±0.26 ^b	17.13±0.61 ^c

Each value is represented as the arithmetic mean±SD (n=3); Different superscripts in the same column indicate the values are significantly different ($p \leq 0.05$); T₁: Unsalted and dried in a mechanical drier; T₂: Salted and dried in a mechanical drier

might be due to the loss of water from the muscle of fish by dehydration and evaporation thereby reducing the water activity and increasing the shelf life of dried Pangasius. A fish well dried or moisture reduced to 25% will not be affected by microbes and if further dried to 15%, the mould growth will cease thereby increasing the shelf life (Clucas, 1982). The moisture content was below 15% indicating that the product was of good quality. According to Lakshman et al. (2015), the proximate composition of fish varies with species, sex, body, season, environmental factors and even type of muscle. Meena et al. (2015) reported a moisture content of 21.22% in dried lizard fish. Thippeswamy et al. (2001) reported a decrease in the moisture of milk fish dried at 60 °C for 24 hrs from 73.55% to 25.82%. The moisture content of hairtail fish meat gel dried at 65°C for 20 hours decreased from 80.50% to 4.0% (Hu et al., 2013).

The protein content of salted and unsalted mechanically dried Pangasius at 60°C increased during drying with values of 60.50 and 67.75% respectively (Table 1). The lower protein content of salted dried Pangasius than the unsalted dried Pangasius was probably due to the leaching effect of proteins during salting. The increase in protein content might be due to removal of water molecules during drying process (Ninawe and Ratnakumar, 2008). Chukwu and

Shaba (2009) reported an increase in protein content from 19.51% to 53.10 and 67.21% in kiln dried and electric oven dried catfish (*Clarias gariepinus*) respectively.

The fat content of salted and unsalted mechanically dried Pangasius increased with the loss of water content and the values of fat content were 11.81% (unsalted) and 8.26% (salted) from an initial value of 2.29% (Table 1). The lower fat content observed in salted mechanically dried Pangasius might be due to the oxidation of lipids. Meena et al. (2015) reported a fat content of 5.86% in dried lizard fish. The fat content has increased from 12.85% to 28.03% and 20.25% in kiln dried and electric oven-dried tilapia respectively (Chukwu, 2009).

The ash content of salted and dried Pangasius (17.13%) was higher than unsalted dried Pangasius (4.26%) from an initial value of 1.44% (Table 1). The increase in ash content of salted mechanically Pangasius might be due to the uptake of salt by the muscles of fish. Meena et al. (2015) reported an ash content of 27.31% during drying of lizard fish. The ash content has increased to 3.92 and 3.62% in kiln dried and electric oven dried catfish (*Clarias gariepinus*) respectively from an initial value of 3.06% (Chukwu and Shaba, 2009).

3.2. Changes in Physico-chemical parameters

A decrease in pH was observed in unsalted and salted dried Pangasius with values of 6.13 and 5.63 respectively (Table 2). The lower pH in the salted mechanically dried Pangasius might be due to the increase in acidic compounds due to salting. Chabbouh et al. (2011) reported a decrease in the pH of salt dried beef meat from 5.57 to 5.40.

The TVBN value of unsalted mechanically dried Pangasius (24.75 mg N100 g⁻¹) was higher than salted mechanically dried Pangasius (18.25 mg N100 g⁻¹) (Table 2). The increase in TVBN might be due to the formation of volatile basic compounds i.e. trimethylamine and ammonia by enzymatic degradation and bacterial spoilage (Vega-Galvez et al., 2011). An increase in TVBN was observed in squid dried at 60°C in hot air dryer from 8.18 mg N100 g⁻¹ to 44.03 mg N100 g⁻¹ (Deng et al., 2014).

During drying of Pangasius in mechanical drier at 60°C, it

Table 2: Changes in physico-chemical parameters of mechanically dried Pangasius at 60°C

	pH	TVBN (mg N 100 g ⁻¹)	PV (meq of O ₂ kg ⁻¹ of fat)	FFA (% oleic acid)	TBARS (mg MDA kg ⁻¹)	NaCl (%)	Water activity (aw)
Fresh fish	6.73±0.06 ^c	8.14±0.05 ^a	0.05±0.00 ^a	0.01±0.01 ^a	0.06±0.06 ^c	0.73±0.06 ^a	0.96±0.00 ^c
T ₁	6.13±0.15 ^b	18.25±1.87 ^c	2.08±0.01 ^b	0.45±0.01 ^b	0.35±0.6 ^a	NA	0.72±0.00 ^a
T ₂	5.63±0.6 ^a	24.75±0.61 ^b	4.17±0.02 ^c	0.64±0.01 ^c	0.54±0.15 ^b	14.55±0.03 ^b	0.74±0.00 ^b

Each value is represented as the arithmetic mean±SD (n=3); Different superscripts in the same column indicate the values are significantly different ($p \leq 0.05$); T₁: Unsalted and dried in a mechanical drier; T₂: Salted and dried in a mechanical drier; NA – Not analysed



was observed that there was an increase in PV of unsalted and salted dried *Pangasius* with values of 2.08 and 4.17 meq O_2 kg^{-1} respectively (Table 2). Peroxide value of 10-15 meq O_2 kg^{-1} of lipids indicates rancidity (Connell, 1975). The PV of salted and unsalted dried *Pangasius* was below the acceptable limit indicating that the product was of good quality. The increase in PV might be due to the oxidation of fats right amount of air was available during drying. It's a known fact that salt accelerates the rate of oxidation and this might be the reason for the increase in peroxide value of salted dried *Pangasius*. The results were contradictory to Wu and Mao (2008) who observed a decrease in PV from 7.62 (fresh) to 3.76 and 3.89 meq O_2 kg^{-1} in hot air dried and microwave dried grass carp filets.

During drying of *Pangasius* in a mechanical drier at 60 °C, it was observed that there was an increase in TBARS value of unsalted and salted dried *Pangasius* with values 0.35 and 0.54 mg MDA kg^{-1} respectively (Table 2). According to Cakli et al. (2006), TBARS values greater than 3-4 mg MDA kg^{-1} indicates a loss of product quality. The TBARS values were below the acceptable limit indicating that the product was safe. The results showed that some oxidation has occurred during mechanical drying which led to the production of secondary oxidation products. The higher values of TBARS in salted dried *Pangasius* suggest that the rate of formation of secondary oxidation product was greater in salted dried fish than unsalted dried *Pangasius*. An increase in TBARS value was observed after drying of Atlantic salmon at 60°C from 0.24 to 1.47 mg MDA kg^{-1} (Ortiz et al., 2013).

There was a slight increase in FFA during the drying of both unsalted and salted mechanically dried *Pangasius* with values of 0.45 and 0.64 % oleic acid respectively (Table 2). When the FFA value is 0.5-1.5 % oleic acid, most fatty acids begin to be noticeable to the palate (Pearson, 1976). The FFA values were lower than the acceptable limit indicating that the product was of high quality and palatable. The increase in FFA indicates that hydrolysis of lipids has taken place during drying and the enzymes responsible for hydrolysis were not deactivated completely. It was also observed that the FFA value of salted dried *Pangasius* was higher when compared to unsalted dried *Pangasius*. The probable reason for the increase in FFA after salting and drying may be the fact that fishes were salted for 48 hours and during this time the inactivated lipases might have activated and might have hydrolysed lipids till drying of fish. Takiguchi (1996) reported that oxidised fatty acid contents increased during drying and with subsequent storage of *niboshi* and *niboshi* powder. FFA value of mackerel and threadfin bream has increased during the drying of minced meat at 40 °C for 12 hours (Lakshmisha et al., 2012).

The water activity decreased from 0.96 (fresh) to 0.72 and

0.74 in unsalted dried and salted dried *Pangasius* respectively (Table 2). The reduction in water activity might be due to the decrease of moisture in salted and unsalted mechanically dried *Pangasius*. According to Anonymous (2016b), the a_w of the dried product should be less than 0.78. In the present study, the values of a_w were lower than 0.78 indicating that the product was stable and of high quality. Chabbouh et al. (2011) reported a decrease in a_w of salt dried beef meat from 0.90 to 0.66 and opined that decrease in a_w of the salt dried product might be due to bounding of water molecules with NaCl and water evaporation.

The salt content of fresh fish was 0.73% and that of salted mechanically dried *Pangasius* was 11.55% (Table 2). The increase in salt content in salted dried *Pangasius* may be due to the uptake of salt during salting. The salt content of sundried and smoke-dried chela fish was 17.54 and 19.57% respectively (Al-Reza et al., 2015).

3.3. Microbial changes

During mechanical drying, a decrease in total viable counts was observed in both unsalted and salted mechanically dried *Pangasius*. The total viable counts (TVC) of both salted and unsalted *Pangasius* were 1.56 log CFU g^{-1} and 1.07 log CFU g^{-1} respectively and the TVC of fresh *Pangasius* was 2.51 log CFU g^{-1} (Table 3). According to Anonymous (2017), the maximum limit of TVC in the dried fish product is 5 log CFU g^{-1} . It was observed that the TVC was within the limit of acceptability indicating that the product was microbiologically safe. The decrease in TVC might be due to the high temperature prevailing during the drying process. The microbial load of smoke-dried chela fish (1.56×10^4 CFU g^{-1}) was lower than sun-dried chela fish (1.97×10^4 CFU g^{-1}) (Al-Reza et al., 2015). The bacterial counts of salted smoke-dried and ring tunnel dried batashi fish decreased from 2.72×10^5 CFU g^{-1} to 1.14×10^4 and 1.88×10^4 CFU g^{-1} respectively (Rana and Chakraborty, 2016). The decline in the total bacterial count after drying of salted *Pangasius* may be due to high salt and lack of enough free water in fish tissue (Zaki et al., 1976).

Table 3: Changes in microbial count of mechanically dried *Pangasius* at 60°C

	TVC (log (cfu g^{-1}))	<i>E. coli</i> (MPN g^{-1})	<i>Staphylococcus</i> spp. (log(cfu g^{-1}))
Fresh fish	2.51	<0.3	<1
T ₁	1.07	<0.3	<1
T ₂	1.56	<0.3	<1

Each value is represented as an arithmetic mean of 2 estimates; MPN: Most probable number; CFU: Colony forming units; T₁: Unsalted and dried in a mechanical drier; T₂: Salted and dried in a mechanical drier



The *E. coli* in fresh was 0.3 MPN g^{-1} and after drying the *E. coli* was detected in dried samples. According to Anonymous (2017), the maximum limit of *E. coli* is 20 MPN g^{-1} in dried seafood. The *staphylococcus* spp. was completely absent in fresh and dried samples of Pangasius. Very low counts of *E. coli* and *Staphylococcus* spp. indicate the product was prepared in hygienic conditions. Total fungal counts were also not detected due to the lowering of moisture to a level where 13.41 and 13.56% in unsalted and salted mechanically dried Pangasius respectively (not shown). According to Anonymous (2017), the maximum limit of TVC in the dried fish product is 500 CFU g^{-1} ($2.7 \log \text{ CFU g}^{-1}$). The total fungal counts of sundried and smoke-dried chela fish were $1.84 \times 10^2 \text{ CFU g}^{-1}$ and $1.13 \times 10^2 \text{ CFU g}^{-1}$ respectively (Al-Reza et al., 2015).

3.4. Sensory changes

The sensory scores of salted and unsalted mechanically

dried Pangasius are given in Table 4. From the results, it was observed that odour, flavour and appearance of unsalted and dried Pangasius were higher than salted and dried Pangasius. The texture and taste of salted dried Pangasius were greater than unsalted dried Pangasius. The overall sensory scores of salted dried Pangasius (8.54) were higher than unsalted dried Pangasius (8.42). The results indicate that there was not much variation in the sensory quality of salted and unsalted Pangasius but only the texture and taste of salted dried Pangasius were higher than unsalted dried Pangasius. Both salted and unsalted mechanically dried Pangasius was of good quality and was accepted by the panellists. The higher overall scores for salted mechanically dried Pangasius may be due to the aroma and flavour due to the effect of salting indicating that salted mechanically dried Pangasius was more acceptable than unsalted mechanically dried Pangasius.

Table 4: Changes in sensory characteristics of mechanically dried Pangasius at 60°C

	Colour	Appearance	Odour	Taste	Texture	Flavour	Overall acceptability
Fresh fish	8.52 ± 0.08^a	8.56 ± 0.09^b	8.50 ± 0.07^a	8.60 ± 0.70^b	8.64 ± 0.11^a	8.54 ± 0.11^a	8.58 ± 0.08^b
T ₁	8.60 ± 0.07^b	8.62 ± 0.16^{ca}	8.58 ± 0.13^a	8.58 ± 0.08^a	8.66 ± 0.09^a	8.66 ± 0.18^b	8.42 ± 0.04^a
T ₂	8.60 ± 0.1^b	8.50 ± 0.29^a	8.60 ± 0.07^b	8.62 ± 0.04^b	8.60 ± 0.12^a	8.58 ± 0.15^a	8.54 ± 0.05^b

Each value is represented as the arithmetic mean \pm SD (n=10); Different superscripts in the same column indicate the values are significantly different ($p \leq 0.05$); T₁: Unsalted and dried in a mechanical drier; T₂: Salted and dried in a mechanical drier

3.5. Colourimetric changes

The changes in colourimetric characteristics are presented in Table 5. It was observed that L^* value decreased in unsalted dried Pangasius (32.21) and increased in salted dried Pangasius (65.95). The a^* value has fallen in both salted and unsalted dried Pangasius from 12.81 (fresh) to 9.82 (unsalted dried) and 2.37 (salted dried) respectively. Similarly, b^* value also decreased from 20.37 (fresh) to 19.45 (unsalted dried) and 16.10 (salted dried) respectively. Hu et al. (2013) reported a low whiteness in hot air-dried hairtail fish meat gel dried at 65°C and opined that the decrease in

Table 5: Changes in colour characteristics of mechanically dried Pangasius at 60°C

Period	L^*	a^*	b^*
Fresh fish	56.83 ± 1.10^b	12.81 ± 1.16^c	20.37 ± 0.85^b
T ₁	32.21 ± 2.65^a	9.82 ± 0.94^b	19.45 ± 0.79^b
T ₂	65.95 ± 3.45^c	2.37 ± 0.37^a	16.10 ± 0.81^a

Each value is represented as the arithmetic mean \pm SD (n=5); Different superscripts in the same column indicate the values are significantly different ($p \leq 0.05$); T₁: Unsalted and dried in a mechanical drier; T₂: Salted and dried in a mechanical drier

whiteness might be due to the longest heating process of hot air drying responsible for Maillard reaction which generated black or brown compounds and reduced whiteness.

3.6. Percentage yield

For drying of unsalted Pangasius, it has taken 60 hours at 60°C with a yield of 29% after drying. In the case of salted and dried pangas, it has taken 42 hours with a yield of 35.2% (Table 6). The higher yield of salted dried Pangasius may be due to the uptake of salt during the salting process and after drying the salt will make up to the weight.

Table 6: Percentage yield after mechanical drying of Pangasius at 60°C

Drying	Time (in Hours)	Temperature ($^\circ\text{C}$)	Moisture (%)	Yield after drying (%)
T ₁	60 hrs	60°C	13.41%	29%
T ₂	42 hrs	60°C	13.56%	35.2%

T₁: Unsalted and dried in a mechanical drier; T₂: Salted and dried in a mechanical drier

3.7. Changes in physical characteristics of dried Pangasius during storage

The physical characteristics of mechanically dried Pangasius at 60°C after two months of storage at room temperature

are given in Table 7. It was observed that the texture of unsalted mechanically dried *Pangasius* at 60°C became soft after one month of storage. The soft texture of mechanically dried *Pangasius* may be due to the oozing out of the fat from the interior of dried muscles, thereby indicating that the unsalted mechanically dried *Pangasius* had a very low shelf life due to the softening of muscle. The salted mechanically dried *Pangasius* had a good odour of salted product and the texture of the product was firm even after two months of storage indicating its stability. The stability of salted mechanically dried *Pangasius* might be due to the reduction of water activity and also the salt impregnated might have played a significant role in the stability of the product. From the above results, it was noticed that the unsalted mechanically dried *Pangasius* was not stable and salted mechanically dried *Pangasius* was stable. So, salting and mechanical drying of *Pangasius* can be an appropriate method of preservation than unsalted mechanically dried *Pangasius*.

Table 7: Physical characteristics of mechanically dried *Pangasius* at 60°C after 2 months of storage at room temperature

Condi- tions	Colour	Odour	Texture	Foreign matter
T ₁	Brown	Dried smell	Soft	Nil
T ₂	Whitish	Cured smell, no ammonical odour, salted fish odour	firm	Nil

T₁: Unsalted and dried in mechanical drier; T₂: Salted and dried in mechanical drier

4. CONCLUSION

The quality of both salted and unsalted mechanically dried *Pangasius* was stable physico-chemically and microbiologically. Not much variation was observed in the sensory scores but yield of salt dried *Pangasius* was higher. Salt dried *Pangasius* was stable till two months of storage but unsalted dried *Pangasius* was not stable but had good quality. Hence, it was concluded that salt drying of *Pangasius* is more suitable method of preservation for market size *Pangasius*.

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