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A Study on The Efficacy of Lakadong Turmeric Collected from Selected Regions of Meghalaya.

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ABSTRACT

This study is to evaluate the _Lakadong turmeric‘ which is regarded as the stylish and exquisite variety of turmeric setup in the state of Meghalaya. The assessment was carried out at the State Food Testing Laboratory under the Commissionerate of Food Safety, Pasteur Hills, Shillong. The study represents a brief analysis reflecting the microbial contaminations, chemical contaminants, trace elements like heavy metals and pesticide residues of various _Lakadong turmeric‘ samples collected from different regions of Meghalaya. Collection of samples was done on random sampling from selected part of East Khasi Hills (locality namely; Laban and Lumshngain), West Jaintia Hills (Laskhein and Shangpung), and Ri Bhoi District (Umeit and Mawkhap) respectively. Around 7 (seven) Pure _Lakadong Turmeric‘ samples were tested for the presence of *Escherichia coli*, *Salmonella and Yeasts and Moulds* respectively. However, all tested samples depict absence of bacterial growth, indicating that these _Lakadong Turmeric‘ samples collected and tested are bacteriologically free from pathogens and other bacterial contaminations. Chemical analysis like, Moisture content, Total Ash, and Acid Insoluble Ash (AIA) was also performed in all 7 (seven) turmeric samples and all these samples conform to the prescribed standards as per the Food Safety and Standards Act, 2006. Presence of macro, micro and toxic heavy metals were also assessed to analysed the curcumin content of each _Lakadong Turmeric‘ samples inorder to determine the authenticity of the products. It was observed that samples show value for heavy metals below the Limit of Quantity (LOQ) indicating that all 7 (seven) _Lakadong Turmeric‘ samples shows no interference of trace metals. Curcumin content of all 7 (seven) samples shows variable values ranges from 5-13.80 %. From the study, it was shown that the turmeric sample derive from Laskein region, West Jaintia Hills District have the highest curcumin content of 13.80% respectively.

Keywords: Lakadong, Turmeric, Curcumin, Acid Insoluble Ash (AIA), Moisture Content.

INTRODUCTION

Turmeric which is a perennial plant *Curcuma Longa, Linn*, belonging to the ‗Zingiberaceae family' member- well known as Turmeric, is an upright and leafy plant with a lily like and a very large leaf up to 1.2 m long. Its leaves are oblong, pointed and have funnel-shaped flowers that are yellow in colour. The part of the plant which is used medicinally is the rhizome, is usually boiled, cleaned, and dried, yielding a yellow powder [1]. The ideal soil pH for growth is between 4.5 and 7.5. It is a 9-month crop, generally sown in late March to early April, when the monsoon (rainy) season starts [2]. According to Shao ZM et al, the dried Curcuma longa product is the source of the spice turmeric, the ingredient that gives curry powder its characteristic yellow colour. Turmeric powder is a well-known spice containing natural antioxidants and especially yellow pigment of turmeric powder is a phenolic pigment, which is an anti-oxidant that can scavenge superoxide radicals, hydrogen peroxide and nitric oxide [3].

Turmeric was used as an ancient spice, a native of Southeast Asia, used from antiquity as a dye and a condiment. It is cultivated primarily in Bengal, China, Taiwan, Sri Lanka, Java, Peru, Australia, and the West Indies. It is still used in rituals of the Hindu religion, and as a dye for holy robes, being natural, unsynthesized, and cheap. Turmeric is in fact one of the cheapest spices. Although it is used similarly to saffron as a dye, the culinary uses of the two spices should not be confused and should never replace saffron in food dishes. Its use dates back nearly 4000 years, to the Vedic culture in India where it was used as a culinary spice and had some religious significance. The name derives from the Latin terra merita ―meritorious earth‖ referring to the colour of ground turmeric which resembles a mineral pigment. It is spread throughout tropical and subtropical regions of the world and is generally cultivated in Asiatic countries, mainly in India and China. ‗Haldi' is traditionally known in India whose rhizomes are oblong, ovate, pyriform, and often short branched [4, 5, 6]. According to MOFPI, 2021, India produces almost 80% of the world's turmeric and meets nearly 60% of the world's exports.

Meghalaya is home to numerous spices, including the well-known turmeric (C. Longa L.). Meghalaya's Jaintia hills districts are home to the Lakadong variety of turmeric, which is regarded as one of the best in the world due to its higher curcumin content. It is known as shynrai or chyrmit Lakadong in Khasi. The tiny community of Lakadong, situated in the foothills of the Jaintia Hills (25°11' N, 92°17' E, Meghalaya, India), is named after the valuable spice Lakadong turmeric [Figure 5]. As Manjit K R, 2023 explains that the tribes of this area transplanted Lakadong turmeric from the forest century back and domesticated it for medicinal and traditional rituals. The varieties commonly grown in Meghalaya are Lakadong, Lashien, Ladaw, Lakachain, Yangau, and Megha-1[7]. Lakadong turmeric has a curcumin content of more than 7% [8, 9, 10, 11], compared to 2–4% in typical turmeric varieties available in the market. It has a significantly darker color compared to other turmeric varieties in India. Lakadong turmeric has the potential to transform the livelihoods of thousands of Meghalaya's small and marginal farmers if effectively marketed. Manjit K R, 2023, points out that unfortunately, due to the growth of local coal industries and the gradual decline in the market the production of Lakadong turmeric has been strongly affected and therefore reduced. However, turmeric is now grown almost everywhere in the state, the Jaintia Hills still has the most land under cultivation and produces more than half of the total turmeric produced in the state. Lakadong turmeric farming is mostly practiced in Sumer, Lakadong, Shangpung, Iooksi, Nongryngkoh, Khonshnong, Umchalait, and Saphai. Lakadong turmeric has been domesticated by the people of this region for over a century. According to reports, Lakadong is also associated with the ―Thanksgiving‖ and ―Children's Naming‖ ceremonies among the Pnar community of Jaintia Hills. During the ceremony shortly after the child's birth, turmeric is held on a bronze plate with dry fish. It was

cut into a square shape and tied around the baby‘s hands to keep them safe from potentially hazardous falls, accidents, or injuries [7]. Recognizing the need to maximize the potential of this variety, the Directorate of Horticulture, Department of Agriculture, Government of Meghalaya has launched the ―Lakadong Mission (2018-2023)‖ to increase Lakadong turmeric production, post-harvest management, processing, and other related activities in Meghalaya‘s Janita hills districts [12]. AgNext Technologies, in collaboration with the Spices Board of India, has used its cutting-edge curcumin testing technique to examine the Lakadong turmeric of Jaintia Hills. According to a press release by the company, AI-based technology is being deployed for the first time in Meghalaya for rapid quality testing of Lakadong turmeric [13].

Medicinal plants have become a dependable source for the preparation of new drugs which helps to combat the diseases, from the dawn of civilization [14]. Turmeric powder has numerous health benefits, including anti-protozoal, anti-inflammatory, anti-venom activities and anti-tumour activity, and is used widely in the cosmetics and pharmaceutical industry [15]. Major bioactive components of turmeric are curcuminoids, such as curcumin (CUR), desmethoxycurcumin (DMC), and bisdemethoxy - Curcumin (BDMC) [16] Turmeric has been found to be effective against the pandemic of COVID-19 due to its ability to restrict cytokine storms in patients suffering from the disease (17-27). In Recent studies turmeric have been authenticated as an anticancer, anti-diabetic, antioxidant, hypolipidemic, anti-inflammatory, antimicrobial, anti-infertility, anti-venom, hepatoprotective, nephroprotective, anticoagulant, etc. The plant was also observed to possess activity against anti HIV and has the ability to combat AIDS [28]. The nutritional composition of turmeric was found to be, water (80–90%), followed by carbohydrates (around 13%), proteins (2%), minerals (2%), and lipids (<1%), [28]. However, turmeric contains two key components: Curcuminoids and essential oils (primarily terpenoids), responsible for the herb‘s orange-yellow colour and aromatic flavour [29]. These components also have a broad spectrum of bioactivities for which data has been confirmed at all levels of investigation, including in vitro and in vivo tests and human clinical trials. Curcumin, the primary and most abundant curcuminoid in turmeric, has been widely examined in pharmaceutical investigations for its bioactivity [30]. The anti-diabetic and cardioprotective properties of turmeric have piqued the interest of many researchers in learning more about the role of turmeric and related bioactive components in preventing cardiovascular diseases (CVD), a leading cause of death worldwide [31]. Curcumin, the main constituent of curcuminoids, has anti-inflammatory, antioxidant, antimalarial, anticancer, hypolipidemic, and immune enhancer properties against life-threatening viral illnesses [Figure 4] [32, 33, 34].

Curcumin was used to treat various inflammatory diseases in ancient Indian medicine, including sprains and swellings caused by injury, wound healing, gastrointestinal issues, colds-cough, bronchitis, conjunctivitis, and liver disorders [35]. Ethanolic extract of turmeric and a curcumin ointment provides excellent relief in those with external malignant tumours [36, 37, 38]. Curcumin is a robust metal chelating agent and an effective free radical scavenger as an antioxidant [39, 40]. Thousands of in vitro and in vivo research on its pleiotropic mechanism of action and therapeutic promise against a broad spectrum of disease conditions, including cancer, neurological disorders, and Alzheimer‘s disease, have been published [41, 42, 43]. The oral administration of turmeric and curcumin is safe for humans and animals. They are also safe during pregnancy, but further human research is needed [44, 45]. Curcumin has been shown to target multiple signaling molecules and function at the cellular level, supporting its various medicinal benefits [46]. Curcumin has anti-inflammatory and antioxidant properties, which supports its potential health benefits [46, 47, 48, 49]. Curcumin is accessible in various medicinal forms, including

energy drinks, ointments, tablets, capsules, cosmetics, and soaps [50]. Recent pH-sensitive curcumin formulations allow more specific and effective targeting of inflammation locations, especially in the gastrointestinal system [51].

Since turmeric is a spice which is extensively used not only for culinary purposes but for medicinal uses as well it is highly subjected to adulteration, where the turmeric is often mixed with artificial colours, dyes, metanil yellow, lead chromate, to give it that bright colour which is perfect and produces a smooth texture. There are some cases where chalk powder, raw rhizomes or even wild turmeric are used to for the manufacturing of haldi powder, which makes it unfit for consumption. Therefore, periodic analysis of the turmeric is necessary to eradicate the risk of adulteration.

STUDY AREA

The Lakadong Valley in Meghalaya's scenic West Jaintia Hills is well-known for its unique turmeric known as Lakadong Turmeric. Owing to the favourable soil, temperature, and environmental factors, this wonder spice has an extraordinarily high curcumin level.

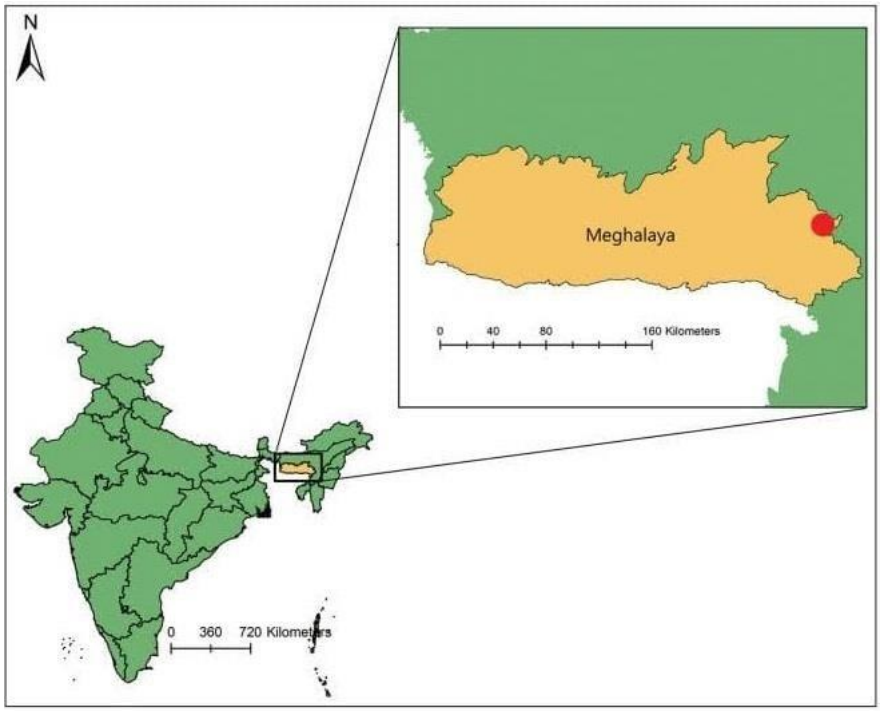

Fig 1: Map of the study area of Lakadong Turmeric, the red msrk represents the location of the Lakadong turmeric (Manjit K R, 2023)

MATERIALS AND METHODS

Microbiological Analysis

1. Sample collection:

For this study, turmeric samples were collected from different regions of Meghalaya to analyse the efficiency of Lakadong turmeric.

2. Procedure for Sampling:

The turmeric used for analysis in this study was the turmeric belonging to Lakadong, these samples were collected from five different sources around Meghalaya, India. The samples were analysed at the State Food Testing laboratory, Pasteur Hills, Shillong, Meghalaya. An inoculum for the test was prepared in a

culture tube where 1 gram of the sample was taken and 9 ml of Milli Q water was added. The culture tube was vortexed for 1 minute and further enumeration of the different microbial count was performed using the following methods:

a) **Enumeration of Total Viable Count: Standard Plate Count (**SPC) test can be used to measure the bacteriological quality of turmeric streaking method was used for inoculating the sample into the designated media**.** After sample inoculation, the plates were sealed and incubated for 24 hours at 3537°C. Examine the number of colonies growth is reported that the present of bacteria into the turmeric sample.

b) **Enumeration of *Yeasts and Moulds* Count:** For this particular analysis Chloramphenicol Yeast Glucose Agar (CYGA) was used as the media. For this test, 7 numbers of petri plates were sterilized and 30 ml of the media was poured in each plate, after the media has solidified, the cultured samples were streaked into the media. After this, the plates were kept in an inverted position, aseptically sealed and incubated at 22-25°C for 48 hours.

c) **Enumeration of *E. coli*:** For the analysis of *E. coli,* Eosin Methylene Blue agar (EMB) was used as the media for inoculating. The samples were streaked on the selective media and were incubated at 35-37˚ C for 24 hours.

d) **Enumeration of *Salmonella*:** For analysis of *Salmonella,* Xylose Lysine Deoxycholate (XLD) was used. The samples were streaked on the selective media and were incubated at 35-37˚ C for 24 hours.

Chemical Analysis:

1. Moisture content

An aluminium dish and cover is being tare weigh and then accurately weigh 2-5 g of the sample into the dishes by using only enough samples to sufficiently cover the bottom of the dish but not less than 2 g. The cover is replaced and stored in desiccator until all have been weighed and before placing dishes in the oven, the lid is being removed and placed under dish. The dish and cover is placed in vacuum oven, which is previously warmed to 105 degree Celsius for 2 hours. After 2 hours, the sample dishes are removed from the oven, and immediately transferred to desiccator and cool to ambient temperature. The sample is weighted to nearest 0.0001 g and calculates to percentage.

Calculation: Moisture content (% by mass) = $\frac{\text{Initial Weight - Final Weight}}{\text{Initial Weight}} \times 100$

2. Total ash

Approximately 2 g of the prepared sample is weighted into the tarred dish. About 2 ml of ethanol is poured on the material and ignited. When the ethanol is burnt off, the dish is heated carefully over a small flame to char the material and then ignite in a Muffle furnace at 550 ± 25 °C for 3-4 h. The ash is then cool and wet with a few drops of water; it is then evaporated carefully to dryness and heated in the Muffle furnace for a further 1 h. If the wetting shows the ash to be carbon free, the dish is removed to the desiccator containing an efficient desiccant and allowed it to cool and weighted. If the wetting shows presence of carbon, the wetting is repeated and heated until no specks of carbon are visible and ignited in the Muffle Furnace for 1 h after the disappearance of carbon. If carbon is still visible, the ash is leached with hot water, filtered through ash less filter paper, the filter paper is washed thoroughly and then the Filter paper and contents is transferred to ashing-dish, dried and ignited in Muffle furnace which is set at 550 ± 25 °C until the ash is white. When the dish is cooled, the filtrate is added and evaporated to dryness on a water Bath. It is then heated in Muffle furnace again, cool in a desiccator and weigh as previously, then heat

again in the Muffle furnace for 1 h, cool and weigh. These operations until the difference in weight between two successive weighing is less than 0.001 g. The lowest weigh is recorded

CALCULATION:

$$\text{Total ash\% by mass} = \frac{W2-W0}{W1-W0} \times 100$$

Where, W0 =mass of empty dish, in g, W1=mass of dish and test portion, in g, W2 =mass of dish and total ash, in g, Where, M = moisture content of sample as received, in %.

3. Acid insoluble ash

15 – 25 mL of HCl solution is added to total ash of sample and boil for 10 min in the boiling water bath, the dish is covered with a watch glass to prevent spattering. The contents of the dish are filtered through the ash less filter paper. The dish and the filter paper are washed with hot water until the washings are free from hydrochloric acid (about 6 to 8 times). The Absence of hydrochloric acid is tested with silver nitrate solution. (Note: Lack of turbidity when a portion of silver nitrate solution is added to the filtrate indicates absence of hydrochloric acid). The filter paper with is returned to the dish and it is evaporated on water bath and ignite it in the Muffle furnace at 550 ± 25°C for 1 h (or until the ash is carbon free). When carbon-free ash is obtained, the dish is transferred to desiccator, cool to 25 ± 2 degree and weigh immediately. The operation is repeated of igniting, cooling and weighing until the difference between successive weighing does not exceed 0.001 g.

CALCULATION:

$$\text{Acid insoluble ash (\% by mass)} = \frac{(W2-W0)}{(W1-W0)} \times 100$$

Where, W0 =mass of empty dish in g, W1 = mass of dish and test portion in g, W2 = mass of dish and acid insoluble ash in g, Where, M = moisture content of sample as received, in %.

High End Equipment

1. Inductively Coupled Plasma Mass Spectrometry (ICPMS)(AOAC Official method 2015.01)

Apparatus used:

a) Instrument and equipment: ICPMS, Peristaltic pump, chiller, exhaust fan, PC, microwave digester, fume hood, weighing machine, homogeniser, and vortex.
b) Standards: Pb, Cd, Hg, As,Sn,Cu)
c) Acids and Reagents: Nitric Acid, HCL, Hydrogen peroxide and tune solution.
d) Milli Q water, centrifuge tubes (50ml and 15ml), pipettes (1ml, 200µl, 110µl, and 20µl), sample (turmeric), tissue and baking paper.

SOP for standard preparation:

a) Gold solution is prepared by using 2% Nitric acid for 50ppm concentration.
b) Internal standards are reduced to 10ppm concentration.
c) Individual stock concentrations are prepared in 10ml tubes.
d) Intermediate standards (mixed standard) is prepared in 50ml tube. Final volume is made up to 25 ml using distilled water.
e) Standards 1 to 6 are prepared along with reagent blank for preliminary run.
f) After vortexing each standard keep them in a standard rack.

g) 2% nitric solution is used for rinsing.

Sample Preparation:

a) Take the microwave vessels and label them as reagent blank, sample blank and spike.
b) Weigh 0.2 gms of the homogenised sample for sample blank and spike.
c) Spike with the known concentration in spike sample.
d) Add the required volume of nitric acid, hydrogen peroxide, HCL and gold solution in all the vessels.
e) For vessels used for balancing, add water with the same volume as others.
f) Keep the sample for pre digestion in fume hood for 30 minutes
g) Set the microwave digester program as
   - Ramp time: 40 minutes
   - Holding time: 30 minutes
   - Temperature: 210 degrees Celsius
   - Power: 1500 W
h) After 30 minutes pre-digestion, keep the sample in the microwave digester reaction.
i) Exhaust fan should always be kept switched on.
j) Add 100µ of prepared internal standard into 50ml centrifuge tubes.
k) Transfer the sample into the tubes and fill with mill Q- water up to the make-up volume and vortex.
l) Transfer the clear solution into the 10 ml tubes and keep in the sample rack for analysis.

Liquid Chromatography Mass Spectrometry MS (LC-MS/MS) (AOAC Official 2007.01)

1. **Pesticide detail**: Acetamiprid, carbendazim, imidacloprid, triadimefon.
2. **Equipments used**: LC-MS/MS, cooling centrifuge, analytical balance, micropipettes (10-100µl, 100-1000µl), graduated centrifuge tubes (50ml and 15ml) cyclomixer and mixer grinder.
3. **Chemicals and reagents**: Water MS grade, reference standards/ CRM traceable to 17034 standards, acetonitrile-MS grade, QuEChERS (Quick, Easy, Cheap, rugged) salt, ammonium formate, formic acid, acetic acid, magnesium sulphate, sodium acetate, Primary Secondary Amine, Graphite Carbon Black.
4. **Preparation of 1mg/kg intermediate pesticide stock standard:**
   Accurately transfer about 100µl of 100mg/kg of Restek Pesticide Reference Standard Mix into a 15ml PP centrifuge tube and dissolve with acetonitrile (MS Grade) then vortex for 1 minute.
5. **Sample Preparation**

Weigh 2 gms of homogenised sample into a 50ml centrifuge tube, add 15ml of 1% acidified MS grade water, shake for 30 seconds, add 15ml of MS Grade Acetonitrile and vortex for 1 minute. Add 6 gm of magnesium sulphate and 1.5gms of sodium acetate. Shake for 1 minute; an exothermic reaction will take place whereby further vertexing for 1 minute is required. The sample was then centrifuged at 7500 RPM for 10 minutes. The extraction solution was carefully pipetted out of about 500µl to a vial and this was followed by adding 500µl of ultra-pure water and kept for injection into the LC-MS/MS. The individual compound result is expressed as mg/kg.

Determination of curcumin content of turmeric: (IS 10925: Specification for turmeric oleoresin by Bureau of Indian Standards)

This standard prescribes the requirements and methods of sampling and test for turmeric oleoresin

1. Equipment used: Double beam UV-Visible spectrophotometer, Model: Dynamica Halo DB-20R Spectrophotometer
2. Reagents: Ethyl alcohol (or suitable denatured alcohol)- 95%
3. Description: weigh accurately 0.1gm of the turmeric oleoresin sample into a small beaker and transfer into a 100 ml volumetric flask with alcohol. Dilute to mark with alcohol and pippette 10 ml of this solution into another 100ml volumetric flask. Dilute to volume with the alcohol. Measure the absorbance of the extract at 425nm in 1cm cell against an alcohol blank.

RESULTS AND DISCUSSION:

MICROBIOLOGICAL ANALYSIS:

Table1. Microbiological status of turmeric samples collected from different regions of Meghalaya.

Sl no.	Parameters	Media used	Turmeric Samples Collected from Different Regions of Meghalaya						
			Laban	**Rynjah**	**Mawkhap**	**Umeit**	**Laskein**	**Laskein**	**Shangpung**
1.	***E. Coli***	Eosin methylene blue (EMB) Agar	Absent	Absent	Absent	Absent	Absent	Absent	Absent
2.	***Salmonella***	Xylose Lysine Deoxycholate (XLD) Agar	Absent	Absent	Absent	Absent	Absent	Absent	Absent
3.	***Yeast & mould***	Chloramphenicol Yeast Glucose Agar (CYGA)	Absent	Absent	Absent	Absent	Absent	Absent	Absent

From the above table, it can be reported that there are no significant growths observed from all the samples of Lakadong turmeric powder collected from different regions of Meghalaya, which they are grown or cultured in their respective culture media. According to the limits put forth by the Food Safety and Standards Act, 2006 for turmeric powder showed that there should be less than or no significant growth per g. Thus, the samples can be considered safe, in a hygienic condition, and without risk level for the public‘s health.

The results observed showed that the Lakadong turmeric samples from different regions of Meghalaya indicate hygienic handling of the spices before and during their storage. Fungal counts are absent which showed that there is no fungal contamination as fungal growth can lead to off-flavours, discoloration and changes in the appearance of spices, making the product unacceptable in the market. Fungi can also alter

unfavourable substrates allowing the growth of bacteria. The absence of pathogens like Salmonella is quite encouraging as this could be due to the antimicrobial effects of spices or the inhibitory action of some dominant flora over the others. Absence of *E. Coli* there is no faecal contamination and hence the possibility of enteric pathogens. This study points out that there is the need to check for improving the harvesting, postharvest handling and storage conditions of spices in Meghalaya. Faster drying methods, processing, proper packaging and hygienic, dry storage conditions, decontamination treatments in the wholesale and retail shops all can lead to a spice of improved microbial quality. Environmental hygiene has a definite role to play in the microbial quality of spice and hence must be taken care of to get a spice of improved quality.

CHEMICAL ANALYSIS

Table 2: Parameters and Chemical Analysis of Lakadong turmeric powder from different regions of Meghalaya

Sl no.	Parameters	FSSAI STANDARDS	Turmeric Samples Collected from Different Regions of Meghalaya						
			Laban	Rynjah	Mawkhap	Umeit	Laskein	Laskein	Shangpung
1.	***Moisture***		9.49	9.37%	9.50%	9.27%	9.70%	9.49%	9.08%
2.	***Ash***	7.89	5.78%	6.51%	5.36%	6.18%	6.45%	5.78%	
3.	***Acid Insoluble ash***	1.5	0.7%	1.3%	0.9%	1.3%	1.23%	0.86%	

1.	***Moisture***	Not more than 10% %
2.	***Ash***	Not more than 9 % %
3.	***Acid Insoluble ash***	Not more than 1.5%

The results obtained in the analysis of Lakadong turmeric powder from different regions of Meghalaya is summarized in Table 2. The parameters determined are moisture, total ash and acid Insoluble ash**.**

Moisture:

The determination of moisture content of spices is of importance for many scientific reasons. Water occurs in Foods essentially in two forms, as bound water and as available free water. Bound water includes water molecules chemically or hydrogen bonded to ionic and polar groups whereas free water is that which is not physically linked to the food matrix and which is freezable and easily lost by evaporation or drying. Most of the foods are heterogeneous mixture of substances; they may contain varying proportions of the two types. The moisture content of the Lakadong turmeric powder samples analysed ranged between 9.27% - 9.70%.

Total ash and Acid insoluble ash:

It is observed that results vary from sample to sample. However, levels of moisture, acid insoluble ash, were not consistent in all the samples. The quality of Lakadong turmeric powder can also be assessed by considering the Total ash value and acid insoluble ash value. The ash of spices is the inorganic residue remaining after the organic matter has been burnt away. The ash content can be regarded as a general measure of the quality or grade of the material under investigation and often is a useful criterion in

identifying the authenticity of a food. When a high ash figure suggests the presence of an inorganic adulterant, it becomes necessary to also determine the Acid –insoluble ash. The results of total ash and acid Insoluble ash are summarized in Table 2. It is observed that all the samples have the minimum ash levels which indicate that these samples are of better quality or grade than the other sample analysed which means that if the total ash is higher it indicates the presence of carbonates, phosphates, silicates in the sample. The mean acid insoluble ash for the samples analysed is 1.3%. The acid insoluble ash is a measure of sandy material in the spices and the limit Prescribe by FSSAI manual is 1.5 % on dry basis.

HIGH END EQUIPMENTS:

1. Inductively Coupled Plasma Mass Spectrometry (ICPMS)

Table 3: table representing the presence of heavy metals in the turmeric sample collected.

Sl no	Name of the metal	Method used	Turmeric Samples Collected from Different Regions of Meghalaya							Maximum Residue Limits (MRL)
			Laban	Rynjah	Mawkhap	Umeit	Laskein	Laskein	Shangpung	
	1Copper (as Cu)	FSSAI Manual	3.45	3.52	0.77	3.34	4.847	4.342	4.035	5.0
	2Arsenic (as As)		Below LOQ	0.03	0.1	0.082	0.057	0.056	0.050	0.1
	3Cadmium(as Cd)		Below LOQ	Below LOQ	0.03	0.029	0.013	0.014	0.012	0.1
	4Tin(as Sn)		Below LOQ	Nil	Nil	Nil	Nil	Nil	Nil	Nil
	5Mercury(as Hg)		Below LOQ	Below LOQ	Below LOQ	Below LOQ	Below LOQ	Below LOQ	Below LOQ	1.0
	6Lead (as Pb)		0.1	1.78	0.4	Below LOQ	Below LOQ	Below LOQ	Below LOQ	10

***LOQ- Limit of Quantification**

The seven samples of turmeric were digested and analysed, due to fraudulent practices in the food industry it has become the first and foremost concern. Therefore, analytical strategies have been developed for authentication of the origins of agricultural products. ICPMS is a robust, accurate and highly sensitive technique for determining the traceability of heavy metals in food stuff. From the above table, the presence of heavy metals such as Copper, Arsenic, Cadmium, Tin, Mercury and lead was analysed using the Inductively Coupled Plasma Mass Spectrometry (ICPMS), the methods used is put forth by the FSSAI manual, and from the results we can conclude that the presence of heavy metals falls below the Maximum Residue Limit (MRL) which is considered safe.

2. Liquid Chromatography Mass Spectrometry MS (LC-MS/MS)

		regions of Meghalaya							
Sl no	Name of the pesticide	Method used	Turmeric Samples Collected from Different Regions of Meghalaya						Maximum Residue Limits (MRL)
			Laban	Rynjah	Mawkhap	Umeit	Laskein	Laskein	Shangpung	
1	Actameprid	FSSAI Manual	0.0093	0.0093	0.0082	0.0065	Below LOQ	Below LOQ	Below LOQ	0.01
2	Carbendazim		0.0053	0.0053	0.0052	0.0054	Below LOQ	0.0049	0.0074	0.01
3	Imidacloprid		Below LOQ	Below LOQ	Below LOQ	Below LOQ	Below LOQ	Below LOQ	Below LOQ	0.01
4	Triadimefon		Below LOQ	0.0045	Below LOQ	0.012	0.016	Below LOQ	0.0064	0.01

Table 4: Table representing the presence of pesticides in the turmeric samples collected from **different**

***LOQ- Limit of Quantification**

A Large variation of toxic substances such as pesticides, antibiotics and different toxins are found in food. These compounds are usually found in low concentration but in some cases their presence can prove to be harmful for human consumption. LCMS/MS is used to accurately quantify the presence of pesticides residue present in agricultural products and in this study it was found that the presence of pesticides such as Actameprid, Carbedazim, Imidacloprid and triadimefon level among all the samples fall below the Maximum Residue Limits (MRL) and is considered as safe.

Curcumin Content:

Table 5: Table representing the curcumin content of the turmeric samples collecte0d from different regions of Meghalaya.

Sl no	**Name of the pesticide**	**Turmeric Samples Collected from Different Regions of Meghalaya**						
		Laban	**Rynjah**	**Mawkhap**	**Umeit**	**Laskein**	**Laskein**	**Shangpung**
1.	Curcumin Content (%)	5.95	5.66	11.90	12.61	11.97	13.80	11.42

Curcumin is a bioactive compound which is found in turmeric. Among the neutraceutical compounds, turmeric has become one of the most famous product especially; in the state of Meghalaya. Lakadong turmeric which is abundant in _Curcumin‘ compound was analysed and found to show variable result.

The value of curcumin content in all 7 (seven) _Lakadong turmeric' samples collected and analysed ranges from 5.66 % - 13.80 % respectively. From the study, it was observed that Lakadong turmeric sample collected from Laban area, Shillong, Meghalaya has a curcumin content of 5.95%, the turmeric from Rynjah has a curcumin content of 5.66%, the turmeric from Mawkhap has a curcumin content of 11.90% and 12.61%, the turmeric from Umeit, Ri Bhoi District has a curcumin content of 11.97 % and 13.80%; whereas, the turmeric samples from Shangpung and Laskein, Jaintia Hills District has a curcumin content of 11.42% and 13.80 % respectively.

Conclusion

Based on this research, we can conclude that the Lakadong turmeric samples collected from different regions of Meghalaya shows absence of microbial contamination. All Lakadong turmeric samples collected and analysed were within the prescribed standards as per the Food safety and standards act, 2006 based on tested parameters of chemical, trace elements and pesticide residues. However, Lakadong turmeric samples from West Jaintia Hills showed high percentage of curcumin content compared to the other turmeric samples collected from other regions of Meghalaya. The reason for the variation of the curcumin content value in these Lakadong turmeric samples from Meghalaya may be due to the traditional breeding techniques adopted by the farmers and because of the topographical, geographical, and climatic condition of specific region.

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