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RESEARCH ARTICLE

EFFECT OF BOILING TEMPERATURE LEVELS AND DURATIONS ON DRY MATTER, TOTAL ASH, CRUDE PROTEIN AND CRUDE FIBER CONTENTS OF DIFFERENT RHIZOME SET TYPES OF TURMERIC (*CURCUMA LONGA* L.).

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Abstract

Turmeric products such as curcumin, oleoresin and essential oils have coloring and medicinal functions. Boiling and drying are mandatory and quality determining steps in turmeric processing. But most farmers in Ethiopia boil mother and finger rhizome together, and give less concern to boiling temperature levels and durations that probably leads to loss of biochemical and physical qualities of turmeric. Hence this study was initiated with objective of optimizing the boiling temperature level (s) and duration (s) of rhizome set types of turmeric for its quality improvement. Accordingly, the result of this study revealed that almost all of the parameters considered were significantly affected by the treatments or their interaction effects. Temperature levels, durations and rhizome set types independently brought about a significant variation on dry matter, crude protein and crude fiber. Rhizome set types demonstrated significant effect on the color of whole rhizome and powder. Curing percent significant differed according to boiling durations.

Introduction:-

Turmeric mostly grows in South Asia, South Pacific Islands, East and West Africa, Malagasy, Caribbean islands, and the Central America (Sasikumar, 2001). 80% of world turmeric is from India (Chempakam and Parthasarathy, 2008; NMCE, 2007).

Currently high production in Ethiopia is found in Yeki woreda (Tepi area) and according to Zenebe and Bereke-Tsehay (1987) cited in Girma *et al*. (2008), turmeric was introduced in 1971/1972 to Ethiopia by Jimma Research Center and from adaptation results, it did well in areas such as Jimma, Mettu, Tepi, Bebeka, Wonago, Awasa, Mugi, and Bako.

From 2006 to 2009, the average land coverage by spices was 122,700 ha and produced 244,000tons/annum. Low land spices are dominantly produced in regions with potential order in SNNPRS, Oromia, Gambella and Amahara

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National Regional states. In general, the over-all potential for low land spices in Ethiopia is assessed to be 200,000 ha (MOARD,2009).

Turmeric is a tropical perennial herb native to Southern Asia, and perhaps originated on the slopes of the tropical forests of the west coast of South India (Yu, 2006). Turmeric is geographically dispersed about Cambodia, China, India, Indonesia, Lao People's Democratic Republic, Madagascar, Malaysia, the Philippines, and Vietnam. It is extensively cultivated in China, India, Indonesia, Thailand and throughout the tropics, including tropical regions of Africa, America and Australia (Peter *et al*., 2007). Burkill (1966) cited in Peter (2007) stated his believe that the crop spread to West Africa in the thirteenth and to East Africa in the seventeenth centuries, respectively.

The excellence of spices is assessed by its intrinsic and extrinsic characteristics. The former consists of the preservation of chemical principles like volatile oil, alkaloids and oleoresins while the latter stresses physical quality (Purseglove et *al*., 1981). In addition, certain health requirements are also implemented as export quality standard *viz.* pesticide residue aflatoxin, heavy metals, Sulphur dioxide, solvent residues and microbiological quality. However, physico-chemical quality remains the ultimate attribute, while considering export requirement of spices as these properties delineate its grade in the market. The physico-chemical characteristics vary widely depending on the variety, agro-climatic conditions existing in the area of production, harvest and post-harvest operations (Jose and Joy, 2004).

Similar to other spices, primary processing is still being done with traditional means leading to many post harvest quality losses. Most of farmers in Ethiopia boil mother and finger rhizome sets together; similar activity reported by Velappan *et al.* (1993) where farmers in some provinces of India rarely boil bulbs and fingers separately to facilitate uniform boiling and to quicken drying. The other factor with little consideration and care is the way the harvested rhizomes is boiled. The optimum temperature at which rhizomes are boiled, the duration of boiling and types of boiling pots used are not standardized by research in Ethiopia. For illustration, the stage at which boiling is stopped largely, effects the colour and aroma; over boiling spoils the colour while under-boiling renders the dried product brittle (Kandiannan *et al.*, 2009). Additionally, Kemble and Soni (2009) stated that as more the boiling duration the more loss of curcumin and oleoresins will be. Also, little has been done on the extent of value parameters such as volatile oil and oleoresin contents of the high yielding farmer's varieties.

The information that is available is limited on the information that is obtainable on the degree of annihilation of bioactive values of spices throughout food processing. Subsequently the healthy, beneficial physiological properties of spices are attributable to their energetic principles, there is a requirement to assess the availability of the spice active ideologies in their original arrangement when spices are heat treated as in domestic boiling. (Srinivasan, 2005). In Ethiopia farming of spices for centuries has mostly remained old by small farmers (MOARD, 2009). Efforts to produce improved technologies were limited to agronomic practices with little effort to improve product quality, which is highly influenced through its value chain from pre-harvest to postharvest management practices including processing of final products. Moreover, little effort has been made to assess farmer's pre and post-harvest management practices that could be used as a benchmark for improvement works targeting product quality and sustainable supply (Endrias and Asfaw, 2011).

Therefore, studies were necessary to investigate the role of different boiling temperature levels and boiling durations on the quality of turmeric rhizome sets. Hence the following objective: To determine the effect of boiling temperature levels and durations on dry matter content, total ash content, crude protein content and crude fiber content of different rhizome set types of Turmeric (*Curcuma longa* L.) duration of different rhizome set types of turmeric (*Curcuma longa* L.) for its quality improvement.

Materials And Methods:-

Description of the Study Area:-

The experiment was conducted at the Southern Nations and Nationalities' Peoples Regional State, Sheka zone, Yeki Woreda at the Tepi Soil Analysis Laboratory and on the drying structures at Tepi National Spices Research Center in 2010/11 both of which are located in the Tepi town that is about 611 Km from Addis Ababa. It is located at approximate geographic coordinates of 7^{o}30'N, and 35^{o}00E and altitude of 1200 meters above sea level. The experimental site receives a long term mean annual rainfall of 1688mm and has a mean maximum and minimum

temperature of 29.5 ^{o} C and 15.3^{o} C, respectively (Edossa, 1998). The relative humidity of the site reaches 80 to 90%, and the soil is classified as Dystric Nitisol and it is dominated by a loam texture (Girma and Kindie, 2008).

Experimental Materials:-

For this experiment matured (9 months old) rhizomes of turmeric variety Dame was taken from Tepi National Spices Research Center seed multiplication plot. Nine month old rhizomes were preferred because harvesting after nine or ten months after planting the biochemical and dried yield recovery contents were reported higher (Girma *et al.,* 2008). Totally 400 kilogram of fresh turmeric was dedicated for the experiment.

Methods:-

Experimental Design and Arrangement:-

The treatments were arranged in three factors factorial combination of three boiling temperature levels (80^{o}C, 90^{o}C and 100^{o}C) X four boiling durations (30, 45, 60 and 75 min) X three rhizome set types (Mother, finger and mother-finger) in completely randomized design with three replications. The above treatment levels were set based on the fact that most of turmeric producing farmers in Ethiopia boil mother and finger mixture rhizomes together and give little care to boiling duration though 45-60 minutes were believed to be in practice .

Preparations and boiling method of the rhizomes:-

Mature rhizomes of turmeric variety (Dame) were harvested from the seed multiplication site of Tepi National Spices Research Center in February, washed thoroughly, and mother rhizomes separated from finger rhizomes. Rhizomes were left heaped for 24 hours for sweating for better development of aroma and flavor.

Next, three and half kilograms from each rhizome types (mother, finger and mother-finger mix) was taken separately for each treatment. Then, rhizomes were boiled using electrically operated boiling heater. Boiling was performed in laboratory using stainless steel of 10 liter capacity dishes on three hot plates having capacity of 230V and 2850W (SD8, Harry Gestingkeit GmbH, Angermunderstr.12, D-40489, Düsseldorf). During the course of boiling 5 liters of water filled in boiling dish was initially allowed to boil, mean-while each rhizome type put in the boiled water and left for a while until it attained the temperature level required and then heater temperature level was set. While boiling was commenced temperature fluctuations were monitored on interval check using thermometer. And when the specified duration boiling for each treatment was reached then the rhizomes were taken out to a bath of twenty kilogram holding capacity to stop further boiling of rhizomes. Rhizomes were delivered to drying beds as soon as cooled. The boiled fingers were dried in open sun spread with uniform thickness of 5-7cm until they attained optimum moisture where the fingers will snap cleanly with a metallic sound. Closer supervision was followed by stirring the samples in the day time for uniform drying and covering in the night. After drying the rhizomes were polished on stretched wire mesh by hand to remove the rough surface and improve its inherent color. Finally, weight of dried rhizomes and removed corkish layer were separately recorded.

Data Collected:-

Relevant data both for analysis and comparison purposes were recorded at different stages of processing steps. Data on drying durations (hrs.) of rhizomes was recorded as soon as boiled rhizomes were brought to bed. Before and after drying data on dry weight recovery (Curing %), diameter and length shrinkage magnitude (%), weight of corkish layer removed (%) and color of polished whole rhizomes (rating) were recorded. Finally data were recorded on essential (%), dry matter content (%), total ash content (%), crude protein content (%) and crude fiber content (%) from the grounded form of rhizomes.

Total ash content (%TA):-

The percentage of total ash content was determined by using furnace apparatus. It was determined by ignition of known weight (5g) of a sample at about 550^{o}C in muffle furnace till all the organic matter is oxidized and lost as CO_2. The residual represents inorganic constituents of total ash while the loss in weight was taken as the organic matter. Procedurally, weight of empty crucible (W2) was taken and five gram of sample transferred into it (W1).

The crucibles with samples were placed in furnace and waited till the temperature reached 550±10^{o}C. Then the temperature regulator was adjusted at 550±10^{o}C and allowed for 5hr. to ash the mineral. When the final duration was reached the furnace was switched off and waited until the temperature dropped to about 100^{o}C to take out the

crucibles with the help of a pair of tongs. Crucibles (samples) were placed in desiccators for cooling and then after weighed (W3) and the percentage ash content was calculated.

% Total Ash =	W3-W1	X 100
	W3-W2	

Crude protein content (%CP):-

Crude protein content (%) was quantified using kjeldahl (HUAYE - SLO-6, China, Shanghai) apparatus. One gram of oven dried material was placed in the digestion flask, 10g of powdered potassium sulphate, 0.5g of copper sulphate and 25ml of concentrated sulphuric acid were added to it and digestion conducted by placing the flask in an inclined position and heating it below the boiling point of acid for 10min. The temperature was raised until the acid boiled briskly. A funnel was placed in the mouth of the flask to restrict the circulation of air. Heating was continued till the solution became clear. The contents were cooled and diluted by adding 200ml of water. Zinc 0.5g and 50ml of 40% NaOH solution were added to make the reaction strongly alkaline. The contents were mixed and at once attached to the distillation apparatus. In the receiving flask 25ml 0.1N sulphuric acid was taken. When two-thirds of the liquid had been distilled, it was tested for completion of reaction. The flask was removed and titrated against 0.1N caustic soda solution using methyl red indicator for determination of Kjeldahl nitrogen, which in turn gave the protein content (Indrayan *et al*., 2009). The crude protein content was determined with a conversion factor of 6.25 (AOAC, 1990).

% N =	1.401 (V-B)N	X 100
	W x DM%	

Crude protein = % Nx 6.25

Where

V = volume of HCl consumed

B = blank titration

N = normality of HCl

W = weight of sample taken

DM% = dry mater of sample

Total dry matter content (%DM):-

Dry matter or, more specifically, moisture determination is probably the most frequently performed analysis in the laboratory. It is an important analysis, in that the concentration of other nutrients is usually expressed on a dry matter basis (as a percentage of the dry matter). The procedure consisted of weighing the sample into a tarred (previously weighed) pan, placing the sample in a 105°C oven (KARL KOLB N7 220 V1N, West Germany) for 24 h and reweighing (Galyean, 1997). The moisture in a sample was lost by volatilization caused by heat. An empty hot crucible (W1) was weighed and five grams of air dried sample transferred into it (W2) and placed in an oven. The final weight (W3) was taken and dry mater content percentage calculated.

% Total DM =	W3-W1	X 100
	W3-W2	

Crude fiber content (%CF):-

Essentially, the procedure of determining crude fiber involved boiling a fat-free sample of feed with weak acid followed by weak alkali. The loss in weight on ignition of the residue was crude fiber (Galyean, 1997). Fiber content (%) was expressed based on Coarse Fiber Determinater (HUAYE - SLO-6, China, Shanghai) using H_2SO_4 and NaOH solvents, Filter bag (F58), Impulse bag sealer and muffle furnace (KARL KOLB N7 220 V1N, West Germany) and Desiccator.

% CF =	(W3-(W1 x C1))	X 100
	W2	

Where:

W1 = Bag tare weight

W2 = sample weight

W3 = weight of organic matter (loss of weight on ignition of bag and fiber residue)

C1 = Ash corrected blank bag (loss of weight on ignition of bag/original blank bag)

Data Analysis (common for all 3 papers):-
The collected data on different response parameters were subjected to the Analysis of Variance (ANOVA) by using SAS version 9.2 computer software (SAS Institute Inc., 2008). Pearson's correlation analysis was carried out to estimate the association among response variables. Least Significance Differences (LSD) was used for mean separation whenever the treatments have significant different effects.

The fixed effects type model and the ANOVA table lay out have the following form:
Model

$$Yijkl = \mu + Ti + \beta j + \gamma k + (T\beta)ij + (T\gamma)ik + (\beta\gamma)jk + (T\beta\gamma)ijk + \varepsilon\ ijkl$$

Where *i*= mother, finger and mother-finger rhizome sets
j=Tempereture levels=80^{o}C, 90^{o}C, 100^{o}C
k =boiling= 30min, 45min, 60min, 75min
l = 1, 2, 3, …, 108

Result and Discussion:-

Nutritional Composition of Rhizome Sets of Turmeric:-

Dry matter content:-
The data subjected to analysis of variance showed no interaction effects existed among theindependent variables for dry matter content in turmeric rhizomes. However, main effects(individual factor treatments) vis-à-vis temperature levels, rhizome set types and boilingdurations brought about a very highly significant (p=0.0003) variations on the quantity of drymatter, or reversely on moisture content of turmeric rhizomes (Table 8 and Appendix Table 1).The maximum (89.04%) percentage of dry matter was recorded from boiling of rhizomes at100oC; while the lowest (87.45%) was obtained from 80oC. Boiling at 90oC recorded midfalling value, but yielded significantly higher and lower dry matter mean values than the 80oCand 100oC boiling temperature levels, respectively. The experiment results confirmed that anincrease of 10oC in each levels of boiling temperature from 80oC to 100oC, there appearedincrease of 0.91 and 0.68% in mean dry matter.

Table 1:- Analyses of variance for Oleoresin, Essential oil, Color value, Dry matter, Total ash, Crude protein and Crude fiber

SV	DF	Mean Square Values			
		DM (%)	TA (%)	CP (%)	CF (%)
TP	2	23.04***	21.85***	10.16***	3.59***
RM	2	18.14***	3.38***	1.36***	14.68***
DR	3	7.83***	8.81***	2.24***	1.45***
TP*RM	4	0.22^{ns}	2.28***	0.14^{ns}	0.17^{ns}
TP*DR	6	0.81^{ns}	0.91*	0.12^{ns}	0.13^{ns}
RM*DR	6	1.63^{ns}	0.13^{ns}	0.06^{ns}	0.09^{ns}
TP*RM*DR	12	0.81^{ns}	0.70*	0.05^{ns}	0.10^{ns}
ERROR	72	1.08	0.31	0.11	0.12

*NS, *, ** and *** = Non-significant, significant, highly significant and very highly significant differences at 5% levels of probability respectively. DM=Dry matter, TA=Total ash,CP=Crude protein and CF=Crude fiber.*

Rhizome sets responded differently to the dry matter percentage because of boiling.While the largest percent of dry matter was recorded from finger rhizome sets (88.79%)proceeded by mother-finger mix rhizome sets (88.42%); mother rhizome sets contained thelowest mean dry matter content (87.42%). Though insignificant variations existed amongthem, long boiling durations led to massive content of dry matter content. Boiling for 60minfollowed by 75min and 45min recorded the highest but invariable mean values (88.71%,88.44% and 88.23%) of dry matter as per their order, but that of the 30min duration resultedin the lowest (87.46%) mean percentage.

Dry matter content is directly influenced by the final moisture content of the rhizomes undertreatment. The secret lies on level of boiling temperature and boiling durations on differentrhizome set types that directly influence the drying duration and final moisture content.Because treatments, mainly finger rhizomes receiving high temperature and long boilingduration may be forced to loss much of their moisture as compared to those treatmentsreceiving low

temperature gradients for short durations; particularly mother rhizomes. Inaccordance with the current finding Govindarajan (1980) and Sampathu et al. (1988) reportedthat higher moisture content was observed in control (no heat treatment) samples and lowerfor boiled ones. A significantly negative correlation value (r= -0.59***) was noticed betweendry matter content and drying durations showing that the one recorded high value formtreatment or their combination the other got small value (Appendix Table 5).

Total ash content:-

The interaction effect among boiling durations, rhizome set types and temperature levels hadsignificant effect (p=0.0163) on level of ash content of the turmeric (Table 7 and AppendixTable 1). Mother rhizomes boiled at 80oC for 30 and 45 min boiling durations containedstatistically similar and the highest total ash mean values of 13.27% and 13.29%, respectivelyfollowed by boiling of finger rhizomes at 80oC for 30min (13.08%), mother rhizomes boiledat 80oC for 60min (12.69%) and 90oC for 30min (12.45%) and mother-finger rhizomes boiledat 80oC for 30min (12.83%) and 80oC for 45min (12.42%); whereas the lowest value wasrecorded from 100oC for 75min boiling of finger rhizomes (9.95%). The superiority of thetreatment combinations that gave the highest yield (13.29%) is explained by more (14.52%and 25.13%) total percentage value than the grand mean (11.36%) and the least (9.95%) totalash content value. The least value deviated by about 12.41% from the grand mean value.

Total ash content amounts from finger rhizomes treated at 80oC for 30min (13.08%) out yielded the amount of mean total ash from rhizomes boiled at 100oC for 75min boiling(9.95%) which is the least value of total ash content. Similarly, mother-finger rhizomes boiledat 80oC coupled with 30min duration produced high total ash mean value (12.83%), whereasone of lowest values for total ash was recorded from boiling at 100oC for 75min (10.55%).

The overall outcome of this experiment indicated that the amounts of carbon containingcompounds in the rhizomes are affected by temperature magnitudes and duration of stay onboiling. Higher temperature levels for longer boiling durations probably created room formaximum carbohydrate and other organic materials vanishing during boiling and when drying.With regard to the extent of organic compound in each rhizome set types it was observed thatthere exists almost no variation. Very highly significant and positive correlation betweenamount total ash content and dried yield recovered (r=0.39***) was observed indicating theash content increased as dry yield recovery increased due to treatments. (Appendix Table 5).

Table 7:- Interaction effects of boiling temperature levels, boiling durations and rhizome set types on total ash content (%) of turmeric

Treatment	Finger Rhizomes			Mother Rhizomes			Mother-Finger Rhizomes		
	T1	T2	T3	T1	T2	T3	T1	T2	T3
D1	13.08^{ab}	11.90defgh	10.32mnop	13.27^{a}	12.45abcde	11.71efghi	12.83^{abc}	11.52^{fghij}	11.88^{defgh}
D2	12.31bcdef	10.26^{nop}	10.67jklmnop	13.29^{a}	12.06cdefg	10.25^{nop}	12.42^{abcde}	10.79^{jklmnop}	11.09^{ghijklm}
D3	11.34ghijkl	10.28^{nop}	10.81jklmonp	12.69abcd	11.80defgh	10.00^{op}	11.86^{defgh}	10.53^{lmnop}	10.82^{ijklmnop}
D4	10.85ijklmop	11.11hijklmn	9.95^{p}	11.20ghijkl	11.43fghijk	10.07^{op}	11.39^{ghijkl}	10.32^{mnop}	10.55^{klmnop}
CV (%) = 4.86		LSD= 0.90				Grand mean = 11.36			

T1=80^{o}C, T2=90^{o}C and T3=100^{o}C boiling temperature; D1= 30min, D2=45min, D3=60min and D4=75 min boiling durations. Means in the same columwith the same letter are not significantly different (P≤0.05).

Crude protein content:-

Though there was significant interaction effect observed, crude protein content mean values showed very highly significant variation (p<0.0001) due to individual treatment factors (Table 8 and Appendix Table 1), i.e. temperature levels, boiling durations and rhizome set types. Mean separation values pointed out that 30min duration was sufficed to retain the highest (7.38%) mean crude protein percentage than the 45min (7.11%), 60min (6.86%) and 75min (6.74%) durations. Boiling for 75 and 60min yielded statistically similar and smallest crude protein values of 6.74% and 6.86%, respectively. Likewise the highest crude protein content value (7.56%) was attained when rhizomes

boiled at 80^{o}C unlike the 100^{o}C temperature degree that gave the least crude protein percentage (6.50%). There again, taking into account rhizome set types of their protein content, the highest percentage mean crude protein was found in mother rhizomes (7.21%) followed by mother-finger mix rhizomes (7.04%); in the mean time finger rhizomes contained the least crude protein content (6.82%).

Nearly about 4.88%, 7.14% and 2.63% crude protein yield advantages were observed when boiling carried out for 30min duration, at 80oC temperature level and for mother rhizomes, respectively when compared against the overall mean values of each treatment (Table 8). Also difference of crude protein content values between the highest and the lowest percents due to boiling durations, temperature levels and rhizome set types indicated 8.67%, 14.02% and 5.41% crude protein contents, respectively. The above degree of variations in crude protein content because of the three factors under consideration confirmed that the temperature levels have more impact on the crude protein content followed by boiling durations. Rhizome set types showed less degree of divergence in content of crude protein among them.

High and low mean percentage of crude protein values could be explained on the ground of inherent nature of proteins specifically their association with temperature regimes, duration of boiling and composition of protein in rhizome set types. Relatively extra resistance and capability of mother rhizomes to tolerate high temperature permit them to maintain more percent of protein. Supporting the result in this experiment, stated mother rhizomes are superior in protein content percentage than fingers, Chu *et al*. (1993) put forward that crude protein content was significantly higher for mother rhizome set (17.8%) than for finger sets (5.1-13.1%).

Since proteins are enzymes they have little chance to survive at high temperature which likely had lethal effect to majority of protein materials during boiling. When high temperature is accompanied by extensively long boiling duration, increase in loss is inevitable. Moreover, least loss in mother rhizomes could probably be for the reason that more strong and tough forms of proteins are present in them as compared to fingers which are easily liable to heat due to their delicate nature. Moreover protein loss might be associated with the degree of moisture loss during boiling and drying. It was indicated that the total protein content progressively decreased as the moisture content decreased because of boiling and drying (Chassagnez-Méndez *et al*., 2000). Significantly negative (r= -0.58) correlation was observed between amount crude protein content and dry matter, and positive (r=0.42***) with dried yield recovered (Appendix Table 5).

Crude fiber content:-

The data garnered from this experiment showed that the crude fiber was very highly affected ($p<0.0001$) by treatment effect of boiling temperature levels, boiling durations and according to the three rhizome sets (Table 8 and Appendix Table 1). High variation in mean crude fiber content was observed when turmeric rhizomes boiled in different temperature levels with down falling trend when one goes from the lower to the climax. The output revealed that boiling at 80^{o}C heat yielded the highest mean value (7.37%) over the 90^{o}C boiling that gave mean value of 7.06%. In turn the 90^{o}C temperature level yielded high mean crude fiber content than the 100^{o}C that gave the lowest mean value (6.74%) among the three temperature levels. The highest crude fiber content (7.53%) was obtained from 30min duration while the least value was recorded from boiling for 75min (6.85%) boiling duration in which about 6.26% and 6.67% respective relative reductions were recorded.

In dealing with rhizome set types mean content of crude fiber was the highest in mother rhizomes (7.67%) than in mother-finger mix rhizomes (7.10%) and finger (6.40%) rhizomes, and the mix contain averaged while finger rhizomes the lowest content among the three rhizome set types. Mother rhizomes possessed 7.43% and 16.56% more crude protein when compared to the mix and finger rhizome sets respectively; the mix rhizome contained 9.86% higher crude fiber content compared to the finger rhizomes which provided the lowest mean value.

The variations in crude fiber contents, as affected by boiling durations, temperature levels and difference with respect to the rhizome set types, could be associated with the overall mean value for each factor in action. The 30min duration, 80^{o}C level, and mother rhizome sets recorded 3.95%, 4.21% and 7.95% more values, respectively. On the other way, 6.8%, 8.55% and 16.56% difference existed between the highest and lowest crude protein contents for boiling durations, temperature levels and rhizome set types, respectively. It is obvious that the variation existed in rhizome set types is the largest value revealing crude protein content is highly affected by rhizome set types than boiling durations and temperature levels.

The reduction in mean fiber content probably could be break up of lignified plant materials by the high temperature levels and long boiling durations. Also, crude fiber is high in mothers may be because their high dry matter make ups made them potentially resistant to heat and therefore few loss of weight particularly when boiled at low temperature and duration ranges. In addition, mother rhizome sets are characterized by more fibrous nature than their respective daughters. There existed significant and positive correlation (r=0.75***) between crude fiber content with amount of dry yield recovered (Appendix Table 5).

In support of results from this experiment Renard (2005) reported, in the case of pears, the pectin fraction is degraded during boiling. In this respect, short periods do not affect the content in dietary fibre while long periods, over 1 h, lead to losses in the pectin content. Thus, it has been reported that the pectin content in the boiling water can increase upon 400% after one hour boiling, when compared with the pectin content after 20 min boiling. Further experiment result by Tatjana *et al*. (2002) confirmed that during boiling kidney-beans a solubilization of the aforementioned polysaccharides is produced, which results in a decrease of the total fibre content, mainly soluble. Purseglove *et al*. (1981) also discussed that rhizomes maintained more than one season like mother rhizomes in this case, have high accumulation of dry matter while the reverse is in quality.

Table 8:- Effect of boiling durations, temperature levels and rhizome set types on crude protein, dry matter, crude fiber content and diameter shrinkage of turmeric

Treatments	Crude protein (%)	Dry matter (%)	Crude fiber (%)
Boiling Durations			
30	**7.38^{a}**	87.46^{b}	**7.35^{a}**
45	7.11^{b}	88.23^{a}	7.14^{b}
60	6.86^{c}	88.71^{a}	6.89^{c}
75	6.74^{c}	88.44^{a}	**6.85^{c}**
LSD	**0.181**	**0.564**	**0.191**
Temperature Levels			
80	**7.56^{a}**	87.45^{c}	**7.37^{a}**
90	7.01^{b}	88.13^{b}	7.06^{b}
100	6.50^{c}	**89.04^{a}**	6.74^{c}
LSD	**0.156**	**0.489**	**0.165**
Rhizome Types			
Finger	6.82^{c}	88.78^{a}	6.40^{c}
Mother	**7.21^{a}**	87.42^{b}	**7.67^{a}**
Mother-finger	7.04^{b}	88.43^{a}	7.10^{b}
CV (%)	**4.736**	**1.179**	**4.979**
LSD	**0.156**	**0.489**	**0.165**

Means in the same column with the same letter are not significantly different (P≤0.05).

Summary And Conclusion:-

Primary processing is still being done with traditional means leading to many post harvest quality losses. Therefore, studies are necessary to investigate the role of different boiling durations and temperature levels on the quality of turmeric. Accordingly, the result of this study revealed that almost all of the parameters considered were significantly affected by the treatments or their interaction effects. Temperature levels, durations and rhizome set types independently brought about a significant variation on dry matter, crude protein and crude fiber. Again, rhizome set types showed significant effect on color of whole rhizome and powder. Curing percent significant differed according to boiling durations.

Dry matter content was highest for finger rhizome sets, at 100^{o}C and for 60min boiling. Crude protein was at its peak when rhizomes boiled for 30min, at 80^{o}C and for mother rhizome sets whereas the smallest values were recorded from 75min, at 100^{o}C and finger rhizome sets. Crude fiber content was highest at 80^{o}C, for 30min and in mother rhizome sets, whereas minimum at 100^{o}C, for 75min and finger rhizome sets. Mother rhizomes boiled at 80^{o}C for 30 and 45 min boiling durations contained statistically similar and the highest total ash mean values of 13.27% and 13.29%, respectively followed by boiling of finger rhizomes at 80^{o}C for 30min (13.08%), mother rhizomes boiled at 80^{o}C for 60min (12.69%) and 90^{o}C for 30min (12.45%) and mother-finger rhizomes boiled at

80°C for 30min (12.83%) and 80°C for 45min (12.42%); whereas the lowest value was recorded from 100°C for 75min boiling of finger rhizomes (9.95%).

Taking in consideration total ash, crude protein and crude fiber using short duration and lower temperature boiling of mother rhizome sets is regarded as effective. By considering the advantages of reducing the losses of fuel, labor, time, quality and difficulties in turmeric processing, the package of boiling conditions are beneficial to the turmeric growers and processing industries. However, though it could be not easy to control the temperature level in farmers' boiling process, exhaustive practical training sessions need to be put in place in order to make them familiar with the technology. To come up with sound recommendations, however, it would be imperative to repeat the study in replicated season and place.

Table 1:- Analyses of variance for Oleoresin, Essential oil, Color value, Dry matter, Total ash, Crude protein and Crude fiber

SV	DF	Mean Square Values			
		DM (%)	TA (%)	CP (%)	CF (%)
TP	2	23.04***	21.85***	10.16***	3.59***
RM	2	18.14***	3.38***	1.36***	14.68***
DR	3	7.83***	8.81***	2.24***	1.45***
TP*RM	4	0.22 ns	2.28***	0.14 ns	0.17 ns
TP*DR	6	0.81 ns	0.91*	0.12 ns	0.13 ns
RM*DR	6	1.63 ns	0.13 ns	0.06 ns	0.09 ns
TP*RM*DR	12	0.81 ns	0.70*	0.05 ns	0.10 ns
ERROR	72	1.08	0.31	0.11	0.12

*NS, *, ** and *** = Non-significant, significant, highly significant and very highly significant differences at 5% levels of probability respectively. DM=Dry matter, TA=Total ash,CP=Crude protein and CF=Crude fiber.*

References:-

1. Asfaw, K. and Endrias, G. 2011. Production, processing and marketing of ginger in Southern Ethiopia. Academic Journals. *Journal of Horticulture and Forestry*, *Vol*. 3(7):207-213.
2. Chassagnez-Méndez, A., N. Machado, M. Araujo, J. Maia, and M. Mereiles, 2000. Supercritical CO_2 extraction of curcumins and essential oil from the rhizomes of turmeric (*Curcuma longa* L.). *Ind. Eng. Chem. Res*., 39:4729–33.
3. Chempakam, B. and A. Parthasarathy, 2008. Chemistry of Spices. Edited by Parthasarathy, V.A., B. Chempakam and T.J. Zachariah, CAB International, pp: 97-118.
4. Edossa, E. 1998b. Spices research achievements and experiences, Research report No 33.Institute of agricultural research, Addis Ababa, Ethiopia.
5. Galyean, M. 1997. Laboratory Procedures in Animal Nutrition Research. Department of Animal and Food Sciences, Texas Tech University, Lubbock.
6. Girma, H/M., Digafie, T., Ali, M., Derbew, B. and Amsalu, N. 2009a. Effect of stage of maturity at harvest on the quality of different ginger cultivars in Southwestern Ethiopia, In: Lemma Dessalegne, Hailemichael K/Mariam, Asfaw Zeleke, Zemedu Worku, Eshetu Derso, Terefe Belehu and Getachew Tabor, (eds.) Proceedings of the Second Biennial Conference of Ethiopian Horticultural Science Society (EHSS), Volume II. 22-23 January, 2009, Addis Ababa, ETHIOPIA, pp. 96-99
7. Girma, H/M., Digafie, T. and Tekaligne, T. 2009b. Physical parameters, oleoresin and volatile oils content of five pepper (*Piper nigrum* L.) cultivars as influenced by maturity. *East African Journal of Sciences*, 3(2):189-192.
8. Girma, H/M., Digafe, T., Edosa, E., Belay, Y. and Weyessa, G. 2008. Spices Research Achievements. Ethiopian Institute of Agricultural research (EIAR). Revised edition, Addis Ababa, Ethiopia, pp: 27-33.
9. Girma, H/M. and Kindie, T. 2008. The effects of seed rhizome size on the growth, yield and
10. economic return of ginger (*Zingiber officinale* Rose.). Asian Network for Scientific Information. *Asian Journal of Plant Sciences*, 7(2):213-217.
11. Govindarajan, S. 1980. Turmeric-chemistry, technology and quality. CRC Critical Reviews. *Food Science and Nutrition*, 12(3): 199-301.
12. Indrayan, A., P. Agrawal, A. Rathi, A. Shatru, N. Agrawal, and D. Tyagi, 2009. Nutritive value of some indigenous plant rhizomes resembling ginger, Research Paper. Natural products laboratory, department of

chemistry, gurukula kangri university, Hardwar-249 404, uttarakhand, India. *Natural product radiance*, 8(5):507-513.
13. Jose, P. and M. Joy, 2008. Solar tunnel drying of turmeric (*curcuma longa* Linn. Syn. *C. Domestica* val.) For quality improvement. Research Department of Botany, Sacred Heart College Thevara, Kochi 682 013, India. *Journal of Food Processing and Preservation*, 33:
14. 121–135.
15. Jose, P. and Joy, M. 2004. Postharvest processing of spices in relation to export quality.Research Department of Botany, Sacred Heart College Thevara, Kochi 682 013, Kerala. *Everyman's Science, vol.*39(4).
16. Kandiannan, K., B. Sasikumar, K. Thankamani, E. Santhosh, S. Devasahayam and T. John, 2009. Turmeric, Extension Pamphlet. Indian Institute of Spices Research. Niseema Printers and Publishers, Kochi – 18.
17. Peter, V. 2007. Handbook of herbs and spices. Published in North America by CRC Press LLC, 2000 Corporate Blvd, NW Boca Raton FL 33431, USA. Woodhead Publishing Ltd Pp:
18. Purseglove, W., G. Brown, L. Green and R. Robins, 1981. Spices: Volume 1and 2. Longman group limited, London.
19. Renard, C. 2005. Effects of conventional boiling on the polyphenols and cell walls of pears. *J Sci. Food Agric.*, 85:310–318.
20. Sampathu, S.R., N. Krishnamurthy, B. Soubhagya and L. Shankaranarayana, 1988. Studies on quality of turmeric (*Curcuma longa*) in relation to curing methods. *J. Food Sci. Technol.*,
21. 25:152–155.
22. Sasikumar, B. 2005. Genetic resources of Curcuma: diversity, characterization and utilization. Indian Institute of Spices Research, Calicut 673 012, Kerala, India. *Plant Genetic Resources* 3(2): 230–251
23. Sasikumar, B. 2001. Turmeric, Handbook of herbs and spices. Indian Institute of Spices Research, Kerala. Woodhead Publishing Limited and CRC Press LLC. Abington Hall, Abington Cambridge CB1 6AH, England.
24. Srinivasan, K. 2005. Role of spices beyond food flavouring: Nutraceuticals with multiple health effects. *Food Reviews International*,21: 167-188.
25. Tatjana, K., G. Terezija, K. Milica and A. Plestenjak, 2002. Dietary fibre content of dry and
26. processed beans. *Food Chem.*,80:231–235.
27. Velappan, E., K. Thomas and K. Elizabeth, 1993. New technologies for on-farm processing of spices. In Proceedings of Post-harvest Technology of Spices. Spices Board (Govt. of India), Kochi, India, pp: 10-13.
28. Yu, Y. 2006. Comparison of Bioactivities and Composition of Curcumin- Free Turmeric (*Curcuma longa* L.) oils from different sources. A Thesis: Presented to the Graduate School of Clemson University In Partial Fulfillment of the Requirements for the Degree Master of Science Food, Nutrition and Culinary Science. Pp: 1.