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Evaluating the quality of swish oven dried tomato powder

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Abstract
Tomato powder production and consumption is not a very common practice among the Ghanaian people because of its poor sensory quality due to lack of effective processing equipment during its production. Swish oven method of drying tomato powder is a simple and low-cost technology that produces tomato powder with very good and acceptable sensory quality. The study examined the effect of swish oven drying on the quality of tomato powder. The researcher employed both experimental and survey approaches, the first part dealt with laboratory test to determine the nutritional value and microbial load, whilst the second part employed survey questionnaires to solicit the views of 120 respondents on the sensory acceptability of the swish oven tomato powder. The main target of the study were food operators and their customers, who were asked to examined twelve (12) sauces prepared from twelve (12) different samples. Findings of the study showed that, three of the samples which were pre-treated with sodium metabisulphite coded RTSMS1, RTSMS2 and PTSMS1 recorded higher scores of good sensory qualities. The laboratory results also indicated that, the same samples coded RTSMS1, PTSMS1 and RTSMS2 recorded less microbial count. In conclusion the study recommends the use of swish oven as a simple technology that dries tomato faster and produce good quality tomato powder.

Keywords: Tomato, microbial, sensory quality, swish oven, acceptability tomato powder

Introduction
Tomato is one of the most widely grown and consumable agricultural produce in the world and most Ghanaian stable food in one way or the other requires the use of tomatoes (Issahaku, 2014) [10]. Tomatoes are used for preparing soups, sauces, shito and many others to accompany dishes such as boiled rice, yam, wakye, kenkey etc. (Sahni and Choudhuni, 2012) [20]. Tomatoes contains antioxidants properties such as Vitamin C, Lutein, lycopene, beta-carotene. Lycopene, lutein and beta-carotene accumulate in the blood plasma and organs to reduce the risk of heart diseases due to their ability in mapping up and fighting free radicals that can interfere with normal cell growth and activity in the blood (Dominguez *et al*., 2020) [6]. Tomato is one food item that helps to reduce the risk of developing disease such as cancer, stroke and cardio vascular diseases (Mozos *et al*., 2018) [14].
Tomato production is one of the most important farming activities in the dry season in the Northern part of Ghana (FAO, 2011) [9]. Tomatoes are cultivated and harvested heavily at certain times of the year and sold at very low prices, then at certain time within the same year shortly after harvesting they become very scarce and very costly to buy. Lower prices of tomatoes come about in the glut season due to its perishability nature and as a result of that farmers are compel to sell their produce at throw away prices than to allow them to go rotten and wasted. Tomato farmers have challenges in processing and preserving tomatoes because they lack processing equipment and facilities to use in processing and preserving their produce (Rubinson & Kolavalli, 2011) [19]. There are several ways of processing tomatoes, these include processing tomatoes into paste form (puree), processing tomatoes into Katch-up, Juice and into powder form (Issahaku, 2014) [10]. To process tomatoes into paste form can be achieved by the use of cannery, which is a capital-intensive equipment and cannot be afforded by individual tomato farmer from this part of the region (Qiu *et al*., 2019) [16]. Drying then becomes the suitable alternative for post-harvest management of vegetables in this area (Bashir *et al*., 2014) [5]. To Saddique & Brunton (2019) [22], drying is a suitable alternative for post-harvest management of vegetable in developing countries where

cold room chain storage is poorly established and even not available. In some part of the world dried tomato powder are very common and are patronized and consumed even more than other tomato products due to their excellent qualities. But in developing countries, tomato drying is not very common. Dried tomato has not gained any popularity in Ghana because of the poor sensory quality nature of it (Sugar & Kumar, 2010) [24]. In developed countries drying equipment such as dehydrators are used for drying tomatoes and other vegetables into excellent qualities. However, dehydrators are not very common in developing countries including Ghana. To Owureku (2013) [15], farmers use sun drying for processing tomato powder for commercial purposes in the glut season in northern Ghana and since sun dried tomato powder has poor sensory quality and less attractive, consumers do not have interest in patronizing it and that makes it unpopular.

Statement of the Problem

Tomato production in Ghana lacks ready market, storage facilities and lack of reasonable alternative processing methods to prolong their shelf life (Robinson and Kolavalli, 2010) [19]. Due to that, the Ghanaian farmer experience heavy losses of tomato during the peak season which could have been processed and used locally (Owuraku-Asare, 2013) [15]. The pertinent question to ask is, why is it that processing of tomato by drying method is still not successful in Ghana just like in other countries in the world. What kind of special intervention is needed to curb this canker since this issue has been a major concern for tomato farmers in the three northern regions of Ghana.

Objective of the Study

The objective of this study is to;

1. Determine the microbial quality of the swish oven dried tomato powder,
2. Determine the sensory acceptability of the swish oven dried tomato powder.

Literature review

Concept of Tomatoes

Tomatoes are fruits with colours such as green when unripe, deep red when ripe, some have yellow, orange and brown colours. Tomato is considered as a vegetable because of its usage in the preparation of meals, but scientifically tomato is a fruit, it is technically the fruit of the tomato plant but used as a vegetable in cooking and preparation of meals.

Ways of drying tomatoes

There are different ways of drying but the choice of drying method depends on various factors such as the type of product to be dried, availability of dryer, cost of dryer, quality of desiccated product (Bashir *et al*., 2014) [5].

Dehydrators are special equipment designed for the use of drying fruits, vegetables, milk, soups and sauces (Kay and Sharon, 1999) [11]. Rawat (2015) [18] in their studies indicated that, drying with dehydrators is very effective because they have thermostat to control the temperature, they have funs to circulate air continuously and dries food item faster, using dehydrators to dry tomatoes comes with excellent sensory quality, low microbial load and good nutritional values (Kay and Sharon, 1999) [11]. They are capital intensive equipment, they are very costly and cannot be afforded by individual farmers in rural areas, and dehydrators cannot also be used at areas where there is no electricity (Sharon and Martha, 2010) [21].

Solar drying is a modern innovation that uses special equipment in trapping energy from the sun, store and use it directly for drying products (Amoaku-Kwakye and MacArlhur, 2014) [4]. To Qiu *et al*. (2019) [16], Solar drying produce hygienic and quality product because it protects the products being dried from environmental factors such as rain, dust and insects but solar dried tomatoes is less attractive in terms of appearance, it has poor sensory quality, (Mohammed *et al*., 2020) [13].

Sun drying is the commonest among all the methods of drying and is mostly practiced in developing countries, it does not require any skill and capital to start and so it is the cheapest of all the drying methods (Faustina and Rosallina, 2014) [8]. As a result of that farmers often depend on sun to dry their tomatoes which will usually take several days to dry and this often do not produce products with good results (Sugar and Kumar, 2010) [24].

Oven drying is a form of drying that makes use of hot air in an enclose space just like solar but the source of heat may come from gas, electricity, charcoal and firewood, oven drying is faster than sun and solar drying, In Ghana, the most common type of oven used in both urban and rural areas is swish oven, it, can be used at rural areas where electricity is not available (Eva, 2010) [7]. Comparing the various ways of drying tomatoes which the situation critically examined suggests that a low-cost equipment which can dry and process tomatoes into excellent powder without losing its qualities be recommended. Formulation and processing of food into convenient form should be promoted using technology that is easily affordable and adoptable to farmers (Owuraku *et al*., 2013) [15]. Amit *et al*., (2017) [3] said, the main objective of post-harvest technology is to restrict deterioration of product as much as possible, improvement of handling and processing methods will increase the revenue of the farmer, reduce waste and produce quality products to the general public. The purpose of this study is to evaluate the effects of swish oven-drying on the quality of tomato powder, through a survey or information obtained from panelist and food operators.

Microbial load of dried tomato powder

Microorganisms can make both desirable and undesirable changes to the quality of foods, depending on whether or not they are introduced into the food during food preservation and processing. Microbial spoilage is the attack of food by bacteria, fungi and occasionally viruses. (Amoako-Kwakye & MacAthur, 2014) [4].

Sensory Quality and acceptability of Tomato Powder

Sensory quality is said to be the degree of excellence and superiority. Sensory quality issues are very necessary in product development and processes in order for products to be accepted and patronized by consumers. Assessment or evaluating the quality of product is an important pre-requisite for market success. (Siegrist, 2008) [23]. Studies conducted by Agribusiness Development Centre (2001) [2] showed that, consumers have often shown concerned about the quality of food they want to consume. The quality of vegetable is determined by various physicochemical parameters such as colour, shape, PH, total soluble solids dry matter and acidity (Sharon & Martha, 2010) [21].

Methodology

The study considered both experimental and survey approaches, the first part delt with the use of laboratory test to achieve one, where twelve samples were tested at the

laboratory of Savanna Agriculture Research Institute (SAR1) and the Spanish laboratory at the University for Development Studies (UDS) to determine the microbial load. Objective three used questionnaire survey, where a scale of 1 to 5 was employed and graded as 1-extremely disliked, 2-disliked, 3-neither liked nor disliked, 4-liked, and 5-extremely liked which measured the sensory acceptability of sauces prepared with the swish oven dried tomato powder.

Population, Sample Size and Sampling Technique

The total population of the target group was over 1,200 and a sample size of 120 was drawn for the study. The study divided the Tamale Metropolis into four zones, Tamale North Tamale Central, Tamale South and Sagnarigu Sub Metro. In each zone the study first stratified respondents into various areas such as wakye sellers, rice and stew sellers, fufu sellers, fried rice sellers and T.Z sellers. In each zone fifteen (15) food operators and fifteen (15) customers of these food operators were sampled based on purposive sampling method. This made a total sample of sixty (60) food operators and sixty (60) customers.

Data collection Instruments

Data entry and analysis was done using Statistical Package for social sciences SPSS version 160. Frequencies were generated for variables and significant associations tested using ANOVA test. Data gathered using this package were on sensory quality of the product such as colour, aroma, taste and texture from three best product of the study.

Processes

Two varieties of tomatoes were chosen for the study namely roma tomato and petomech tomatoes, 30kg of fresh roma tomato and 30kg of petomech tomatoes were purchased from a farm gate at a firm red ripe stage from a farmer at Dalung in the Kumbungu district in the Northern Region. According to the USDA ERS, (2012) [25] red ripe firm tomatoes on the vine are considered higher quality tomatoes with better flavor. Roma and Petomech tomatoes were chosen because they are good varieties for processing purposes, they have less water content, high plum and good red colour. Samples dried from these two varieties were put into three main group, the control group, samples treated with Sodium-metabisulphite and samples treated with vinegar solution. Total number of samples used in the study were twelve (12) and out of the twelve, six were dried with their skin and seeds, and six also dried without seeds and skin. Samples dried with seeds and skin were lable 1 and samples dried without seeds and skin were label 2

The Control Group/Samples without Treatment

Ten (10) kg of roma tomatoes and ten kg of petomech tomatoes were weighed, washed and cut into 5mm tick. The cut tomatoes were spread in baking. Sheets of 50 x 50, lined with cardboard papers to prevent sticking and labeled for easy identification. RTSS1 (Roma tomato with seeds and skin) RTSS2. (Roma tomato without seeds and skin) PTSS, (Petomech tomato with seeds and skin) PTSS2. (Petomech tomato without seeds and skin). They were put into a pre heated swish oven of seven (7) feet high and five (5) feet diameter wide and dried at a temperature approximately between 55 °C-60 °C for 12-14 hours. It is ideal to dry tomatoes between 55 °C – 60 °C to avoid case Harding (Adimabunu, 2010) [1] Samples without seeds and skin dried within 12 hours while samples containing seeds and skin dried within 14 hours. They were crashed and milled.

Samples Treated with Sodium Metalbisulphite (SMS)

Ten (10) kg of roma tomatoes were divided into two parts one part was dried with seeds and skin and the other dried without seeds and skin. Tomatoes were cut into 5mm thick dipped into 1% sodium metalbisulphite – two liters of water for ten minutes and then drain in a basket before spreading on labeled baking sheets and dried for 10-12 hours. Sulphating helps to enhance drying rate, it helps to plamolyses and shrinks the cells of the products and reduces microbial count, sulphiting helps to prevent enzymatic and non-enzymatic reaction, it enhances the presences of lycopene and conotenoids and it facilitate drying process (Latapi and Baretti, 2006) [12].

Samples Treated with Vinegar Solution

The two varieties of tomatoes weighed 10kg each, various samples were cut and dipped into 1% vinegar solution for ten minutes, drained and spread on labeled baking sheets before putting in a pre-heated swish oven at 55^{0c}-60^{0c} for 12-14 hours. Samples were labeled as follows: RTVS1, RTVS2, PTVS1, PTVS2 and dried. After all the samples were dried, they were crashed, milled and stored in air tight containers with labeles.

Presentation and Discussion of findings

Table 1: Results of microbiological test of dry tomato powder samples

Sample Code	Total Microbial Count(g/cfu)	Yeast and Mould (g/cfu)	*E.Coli*	Salmonella
RTSS1	$1.8x10^3$	$1.2x10^3$	Nil	Nil
RTSS2	$1.6x10^3$	$1.8x10^3$	Nil	Nil
PTSS1	$1.8x10^3$	$1.4x10^3$	Present	Nil
PTSS2	$1.8x10^3$	$1.3x10^3$	Nil	Nil
RTSMS1	$1.4x10^3$	$1.1x10^3$	Nil	Nil
RTSMS2	$1.2x10^3$	$1.0x10^3$	Nil	Nil
PTSMS1	$1.4x10^3$	$1.1x10^3$	Nil	Nil
PTSMS2	$1.2x10^3$	$1.0x10^3$	Nil	Nil
RTVS1	$1.8x10^3$	$1.2x10^3$	Nil	Nil
RTVS2	$1.6x10^3$	$1.2x10^3$	Nil	Nil
PTVS1	$1.8x10^3$	$1.2x10^3$	Nil	Nil
PTVS2	$1.8x10^3$	$1.2x10^3$	Nil	Nil

Analyses of microbial load of swish oven dried tomato powder: Swish oven dried tomato powder was tested at the laboratory to determine the presence and absence of microorganisms which are often associated with tomatoes and tomato product during production and storage. Table 1 shows the microbial load of dried tomato powder, standards set by International Commission of Microbiological Specifications. For Food (ICMS) 2.4 log CFUlg for yeast and 4.0 log CFUlog

for moulds counts are below the allowable limits. Samples pre-treated with SMS recorded lower counts of yeast and mould than samples treated with vinegar solution and samples without pre-treatment. These samples showed no signs of spoilage and off – odours. Literature shows that sulphating helps to plamolysa and shrink the cells of products as well as reduce microbial counts during drying. (Latapi & Baretti, 2005) [12] The next lowest samples were the RTVS2, RTSS1, RTVS1, PTVS1, and PTVS2. These samples recorded $1.2x10^3$ yeast and mould and a total microbial count of 1.6. The untreated swish oven dried tomato powder with seeds and skin had yeast counts of $2.0x10^3$log CFUlog exceeding limits ($log10^3$) which resulted in fermented odours with physical sign of spoilage. *E. Coli* and Salmonella were not detected in any of these dried samples. However, one sample coded PTSS1 without any treatment detected the presence of *E. Coli*. Samples with Vinegar solution also record yeast and mould within the acceptable limits.

Sensory Acceptability of Swish Oven Tomato Powder Based Sauces

To be able to determine if consumers of tomatoes and tomato product would accept this dried tomato powder processed by Swish Oven, a sensory analysis test was conducted with three (3) best samples. Acceptability analyses test was conducted using the five-point scale in four attributes being colour, aroma, taste and texture for the overall acceptability. Table 4 below shows the results of the acceptability test.

Table 2: Tomato powder sauce test conducted by food operators

Sample Code	Attributes	No. of Person	Mean	Standard Deviation	Variance
RTSMS 1	Colour	60	4.45	.598	1st
RTSMS 2	Colour	60	4.20	.971	3rd
PTSMS 1	Colour	60	4.28	.686	2nd
RTSMS 1	Aroma	60	4.22	.605	1st
RTSMS 2	Aroma	60	4.18	.725	3rd
PTSMS 1	Aroma	60	4.20	.688	2nd
RTSMS 1	Sweetness	60	4.20	.681	2nd
RTSMS 2	Sweetness	60	4.45	.598	1st
PTSMS 1	Sweetness	60	4.18	.759	3rd
RTSMS 1	Sourness	60	3.05	.639	3rd
RTSMS 2	Sourness	60	2.75	.716	1st
PTSMS 1	Sourness	60	3.25	.951	2nd

Table 3 presents information from participants showing each attribute after tasting a sauce prepared from swish oven tomato powder. The results displayed indicates the following attributes; colour, aroma, sweetness and sourness, with a test value of 3.5. The mean score for colour RTSMS1 was 4.45 with Std Dev. of 598 this was followed by PTSMS1, which also recorded a mean value of 4.28 and a (SD = 686). RTSMS2 also recorded a mean value of 4.20 and (SD = 971) respectively, implying that, colour for the new product was very significant because the values had exceeded 3.5 of the study. The aroma for both roma and petomech tomatoes of the three samples were 4.20, 418 and 4.22 with Std Dev. of 0.971, 725 and 0.904 respectively, which also implied that aroma for the new product was quite significant. Then means score for sweetness were shown as 420 for RTSMS1, 445 for RTSMS2 and 4.18 for PTSMS1 with Std Dev. of 0.681, 0.598 and 759 and 0.533 respectively this also, implied that sweetness for the new product was significant. The means score for sourness were also revealed as 305, 2.75 and 325 with Std Dev. of 639, 716 and 951, implying sourness for the new product was not all that significant. Since their mean values were less than 3.5 of this study. It was quite evident from the results that the colour of tomato powder was the most recognized attribute of the new product since a good reddish colour ensures the presence of other attributes. The next quality revealed by the study was aroma, it was one of the important attributes desired to food operators. In addition to these, sweetness of the product was also considered a desired attribute of by respondents.

Table 3: Sensory test of tomato powder sauce by customers of food operators

Sample Code	Attributes	No. of Person	Mean	Standard Deviation
RTSMS 1	Colour	60	4.80	.523
RTSMS 2	Colour	60	4.00	.291
PTSMS 1	Colour	60	4.67	.482
RTSMS 1	Aroma	60	4.55	.506
RTSMS 2	Aroma	60	3.52	.156
PTSMS 1	Aroma	60	4.25	.500
RTSMS 1	Sweetness	60	4.52	.510
RTSMS 2	Sweetness	60	4.85	.598
PTSMS 1	Sweetness	60	4.55	.506
RTSMS 1	Sourness	60	3.34	.639
RTSMS 2	Sourness	60	2.75	.716
PTSMS 1	Sourness	60	3.52	.951

The results displayed in table 3 showed the attributes colour, aroma, sweetness and sourness the results of the study revealed a test value of 3.5. The three best samples obtained from the first test were RTSMS1 RTSMS2 and PTSMS1. The mean score for colour of RTSMS1, RTSMS2 and PTSMS1 were 4.80, 400 and 467 with Std Dev. of 0.523, 291 and 482 respectively. Ranking RTSMS1 first, PTSMS1 second and RTSMS2 third. This implied that, the RTSMS1 sample had the best colour among the three samples and was very significant. The mean scores of aroma was 455 for RTSMS1,

3.52 for RTSMS 2, and 4.25 for PTSMS1 with Std Dev. of 0.506, 0.156 and 0.500 respectively. The three samples were ranked first second and third for RTSMS1, PTSMS1 and RTSMS2 respectively. Implying that, aroma for the new product was quite significant because all three have test values more than 3.5. The mean score of sweetness, also recorded 4.52 for RTSMS1, 4.85 RTSMS1 for RTSMS1 with Std Dev. of 0.510, 0.598 and 506 respectively, in ranking these three samples – RTSMS2 was detected to have recorded the highest mean values followed by PTSMS1 and the least was RTSMS. These showed that, all the three samples have more than 3.5 mean values which implied that, sweetness for the new product is quite significant. Then also the mean scores for sourness, were 3.34, 275 and 3.52 with Std Dev. of 639, 716 and 951 respectively. This also implied that, sourness for the new product is not all that significant.

Conclusion

Conclusions drawn after the study of the results showed that, Swish oven dried RTSMS1, RTSMS2 and PTSMS1 were liked by respondents. The three best samples ranked almost the same degree of acceptance and scores. It was concluded from this study that not only because RTSMS1, RTSMS2 and PTSMS1 proved to be the best and most liked as a result of their good colour, aroma and taste but they also recorded good amount of nutrients and very less microbial count as indicated by the WHO standards and standards set by international commission for microbiological specification for food. Swish oven is considered as an urgent alternative to be used by farmers to achieve their goal in drying tomatoes successfully. Using swish oven for drying tomatoes will help reduce the huge losses incurred by farmers year after year and scarcity of tomatoes shortly after the peak season. Postharvest losses occur due to lack of processing facilities to prolong the shelf life of tomato.

Recommendations

The study recommended food operators to patronize this new brand tomato powder which has good sensory quality and also safer to consume than other dried tomato products. The study also recommended the use of swish oven as a simple technology that can assist to improve tomato drying into quality powder, especially when treated with SMS. In addition to its effectiveness and efficiency, swish oven is less expensive equipment and can easily be accessed by local farmers in rural areas because it is built with simple local materials, hence it requires minimum amount of capital to set it up, swish oven as a drying and processing equipment was far better than solar and sun drying. The study also recommended that any future study on dried tomato powder should consider other treatment agents such as potassium metabisulphate (PMS) apart from vinegar and SMS which are already examined in this study. However, the use of swish oven as drying and processing equipment remains a recommended one.

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