IMAGE: A MAP OF THE STARS OF THE ORION CONSTELLATION

Print ISSN: 2631-8490 Online ISSN: 2631-8504

JournalPreview

London Journal of Research in Science: Natural and Formal
Volume 22 | Issue 15 | Compilation 1.0

London Journals Press

LONDON JOURANALS OF RESEARCH IN SCIENCE: NATURAL AND FORMAL

Journal Content
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London Journals Press

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ABSTRACT

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The results showed that the final weight gain, DWG, PWG, FCR and PER of the fish fed diets diet D0, D20, D30, D40, D50 were not significantly different ($P>0.05$) from one another, but were significantly higher ($P<0.05$) than those of the fish fed diets D60. The SGR and survival were not significantly different ($P>0.05$) from one another. The white blood cell (WBC) and lymphocytes ranged between 7.35-8.14 ×103 mm^{-3} and 63.00-72.00% respectively.

Keywords: proximate, disorders, glucanase, amylase, anti-nutrients, haematology.

Classification: FOR Code: 069999

Language: English

London Journals Press

LJP Copyright ID: 925651
Print ISSN: 2631-8490
Online ISSN: 2631-8504

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ABSTRACT

This study examined the physiological responses (hematology and enzyme characteristics) of Clarias gariepinus juveniles (mean weight 29.69 ±0.91g) fed diets with varying levels of fermented cassava (Manihot esculenta) peel and Leucaena leucocephala leaf meal (CPLM), for a period of 10 weeks in the laboratory. Seven iso-caloric and iso-nitrogenous diets were formulated containing 0%, 20%, 30%, 40%, 50%, 60% and 70% CPLM maize replacements tagged diets D0; D20; D30; D40; D50; D60 and D70 respectively.

The results showed that the final weight gain, DWG, PWG, FCR and PER of the fish fed diets diet D0, D20, D30, D40, D50 were not significantly different (P>0.05) from one another, but were significantly higher (P<0.05) than those of the fish fed diets D60. The SGR and survival were not significantly different (P>0.05) from one another. The white blood cell (WBC) and lymphocytes ranged between 7.35-8.14 ×103 mm^{-3} and 63.00-72.00% respectively. There was increase in the WBC and lymphocytes as the CPLM increased in the diet. The results obtained for MCH and MCV showed that the fishes fed diet containing 50% fermented cassava peel meal had the highest values of 47.00 pg and 160.00 fl for MCH and MCV respectively and the least values of 25.56 pg- 88.89 fl were recorded for MCH and MCV in fish fed diets D60 to D70. Considering these effects, it is recommended that cassava peel-Leucaena leaf meal replacement beyond 50% should be discouraged, as replacement beyond this optimum value have indicated poor growth and physiological performances. Fish farmers especially in resource poor regions of the world can take advantage of this ingredient as a replacement for more expensive maize when formulating feed for fish in aquaculture.

Keywords: proximate, disorders, glucanase, amylase, anti-nutrients, haematology.

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I. INTRODUCTION

Feed is one of the major inputs in aquaculture production and fish feed technology is one of aquaculture least developed sectors of aquaculture, particularly in Africa and other developing countries of the world. FAO (1993) have emphasized the utmost importance of using local feed resources as the key driving force to increase the productivity of fish. High cost of fish feed was observed as one of the problems hampering aquaculture development in Nigeria (Adewumi, 2015). Expensive feeds will marginalize or even nullify the profitability of fish farming thereby incapacitating the expansion of farms to increase production resulting in the scarcity of the commodity (fish) and eventually high cost of the few available ones to the disadvantage of the consumers (Adikwu, 1992).

Cassava peel as a cheap carbohydrate source is capable of supplying adequate calories to Clarias gariepinus fingerlings/juvenile with improved

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protein value, through fermentation with biomass from organic sources (Ijaiya, 2001). The starch in cassava is highly digestible when compared to that of maize due to the high content of amylopectin (Talthawan et al., 2002). However, cassava peel, as an energy component of the test diets contains some hydrogen cyanide (HCN) derivatives that have been shown to be toxic to livestock (McDonald et al., 1995) and therefore limits the use of cassava peels in the raw state, as feedstuff.

Phytate, found in cassava products binds with phosphorus in diets and render it non bio-available to any animal that is non-ruminant. Besides, phytate has also been reported to form complexes with proteins at both low and high pH values. These complex formations alter the protein structure, which may result in decreased protein solubility, enzymatic activity, and proteolytic digestibility. In order to prevent goitrogenetic and other neuropathological effect on animals, it will be necessary to process the peels before consumption.

Studies on the use of cassava meal in fish feed indicate that cassava can replace the conventional energy feed ingredients such as maize, broken rice and sorghum, which are commonly used in animal diet in most parts of Africa (Akinfala and Tewe, 2001). Cassava has been successfully used to replace maize in Clarias gariepinus fingerlings (Abu et al., 2010; Olukunle, 2006). Inclusion of whole cassava root meal in the diet of fish enhanced growth and survival. Though cassava is high in carbohydrate content, it is however low in protein content (Tewe and Egbunike, 2007) and has a very high crude fibre. Therefore, the need to fortify the peel with protein is necessary. Glyricidia sepium leaves have been chosen in this study to boost its protein value.

Hematological parameters are good indicators of physiological status of animals and have been found useful for disease prognosis and for therapeutic and feed stress monitoring (Togun et al., 2009; Aro and Akinmoegun (2012).

Hematological constituents reflect the physiological responsiveness of the animal to its internal and external environments which include feeding. Hematological values could serve as baseline information for comparisons of nutrient deficiency. Haematological components of blood are also valuable in monitoring feed toxicity especially with feed constituents that affect the formation of blood in culture fisheries (Oyawoye and Ogunkunle, 1998). Animals with good blood composition are likely to show good performance (Isaac et al., 2013).

In view of the above, the present research was set up with the objective of determining the optimum replacement level of maize meal by fermented cassava peel meal (CPLM) and the effects on growth, haematology and digestive enzymes of Clarias gariepinus.

II. MATERIALS AND METHODS

2.1 Procurement of Materials

The study was carried out at the Animal House of the Department of Zoology and Environmental Biology, Ekiti State University (EKSU), Ado Ekiti, Ekiti State, Nigeria. Fresh cassava peels (2kg) were obtained from Aba Ebira, Iworoko Ekiti, Ekiti State, and fresh Leucaena leucocephala leaves (1kg) were harvested from the Department of Plant Science, EKSU, Ado-Ekiti. Fresh poultry dropping (1kg) was collected from a poultry farm in Iworoko Ekiti. A total of healthy, one hundred and eighty (180) samples of juvenile C. gariepinus (av. weight 29.69 ± 0.91g) were obtained from Mr. Olatunji's farm, Ibadan, Oyo State and transported, in an aerated container, to the Animal House of the Dept. of Zoology and Enviromental Biology, EKSU, Ado-Ekiti.

2.2 Ingredients and Diet Preparation

Two kg of fresh cassava peel wastes collected were cut into small pieces of about 2cm2 sizes. These were exposed to the sun for about 5hours, to wilt. The leucaena leaves were added to poultry droppings and mixed together with the cassava peels. These were packed into black polyvinyl bag, tied and left to ferment for 21 days. After 21 days, the mixture was spread out and sundried for four days after which it was milled, with a hammer mill, into powdery form, tagged fermented cassava peel meal (CPLM). The other feed

ingredients; maize, soya beans, 78% Danish fishmeal, ground nut oil, salt, fish premix, lysine and rice bran, were obtained from Metrovet Venture, Ado Ekiti. They were all in milled form, ready for use in feed formulation.

A 2g sample of the CPLM was taken to the lab for proximate analysis (moisture content, crude protein, ash, fibre, fat and carbohydrate) at the Central Science Laboratory of Federal University of Technology, Akure, Ondo state. Based on the crude protein content of the CPLM, seven diets containing different levels of the CPLM replacement for maize (0%, 20%, 30%, 40%, 50%, 60% and 70%) tagged D0, D20, D30, D40, D50, D60 and D70 respectively, were prepared, using Pearson's method (Table 1).

2.3 Experimental Set Up

The fish were acclimatized for 2 weeks in plastic aquarium tanks, supplied with clean water and fed with conventional commercial fish feed twice daily (8.00am - 9.00am) and (6.00-7.00pm), in order to adapt to the environmental condition before the commencement of the study. After 2 weeks of acclimatization, the fish were fed with the test diets for eight (8) weeks in each plastic bowls. Eighteen bowls were randomly allocated in triplicates, to six treatment diets, and the fish were randomly distributed into the bowls, at a stocking density of 15 juveniles per bowl. Feeding was carried out twice daily. The left-over feeds and faeces were siphoned off promptly and dead fish were promptly removed to prevent contamination.

Table 1: Composition of Experimental Diets (100-1dry Matter Basis) With Varying Inclusion Levels of Fermented Cassava Peel Meals (CPLM).

Ingredient	Diet						
	D0	D20	D30	D40	D50	D60	D70
Fish Meal	28	28	28	28	28	28	28
CPLM	0	3	6	9	12	15	18
Maize	30	27	24	21	18	15	12
Soybeans	19	19	19	19	19	19	19
Rice bran	20	20	20	20	20	20	20
Oil	1	1	1	1	1	1	1
Salt	1	1	1	1	1	1	1
Vit. premix	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Lysine	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Methionine	0.2	0.2	0.2	0.2	0.2	0.2	0.2

2.3 Collection of Blood Samples

Blood samples of a set of three fish were collected at the beginning of the feeding trial (week 0) and at the end of trial (week 8) from each set in each bowl. This blood sample was withdrawn from the caudal peduncle, following the procedure described by Stockopf (1993), Joshi et al. (2000a) and Dienye and Olumuji (2014). Two ml of the blood sample from each fish was collected with 2ml syringe and needle and put in ethylene-diamine tetra-acetic acid (EDTA) bottle. The samples were taken to the laboratory for hematological analysis which involves measurement of erythrocyte values: Haemoglobin (Hb), estimated by cyanomethemglobin method, red blood cells (RBC) and white blood cell (WBC) counted by Neubauer's improved haemo-cytometer, using Hyem's and Turks solution as a diluting fluid respectively. The absolute erythrocyte indices [mean corpuscular haemo-globin concentration (MCHC); mean corpuscular haemoglobin (MCH) and mean cell volume (MCV)] were calculated respectively using standard formula described by Dacie and Lewis (2001) as follows;

- MCHC (%) = Hb x 10
  PCV
- MCH (pg) = Hb x 10
  RBC
- MCV (fl) = PCV x 10
  RBC

2.4 Crude Enzyme Preparation

Ten experimental fish from each sample collection were slaughtered and the gut regions of the fish were pooled, homogenized in an ice cold 20mM phosphate buffer pH 7.0 and the homogenates were centrifuged at 1200 rpm for 30 minutes at 4oC. The supernatants were used as crude enzyme extracts without further purification. Benedict's qualitative reagents were used for the qualitative assay of glycosidases (carbohydrases) following the methods used by Fagbenro et al., (2005) and Olatunde et al. (1988). Glycosidases (maltase, cellulase, glucanase) were assayed in a reaction mixture containing 2.0 ml of phosphate buffer (pH 7.0), 0.4 ml of 1 % of substrate and 0.2 ml of the enzyme extract. The test and control samples were incubated for one hour in a water bath at 37oC. Hydrolysis of polysaccharides and non-reducing disaccharides were determined in terms of the appearance of reducing properties using Benedict's reagents. An aliquot of 5.0 ml of the alkaline copper reagent of Benedict was added to 1.0 ml of the reaction mixture and heated for 30 minutes in a water bath at 100oC. The appearance of brick red to cream yellow precipitate was taken as an index of positive reaction. Quantitative assays were conducted using the dinitrosalicyclate (DNS) methods described by Plummer (1978). Each reaction mixture comprised 0.4 ml of 1% substrate, 0.2 ml phosphate buffer (pH 7.0), 1.6 ml of alkaline 3, 5-dinitrosalicyclic acid reagent (DNSA) and 0.2 ml of the enzyme extract. The reaction mixtures for test and control samples were heated for 30 minutes in a water bath at 100C. Each of the mixtures was made to 4.0 ml by diluting with 1.6 ml distilled water. The amount of reducing sugars produced on enzymatic reaction was estimated colorimetrically and the absorbance read at 550 nm on a spectrophotometer.

2.5 Statistical Analysis

All data collected were subjected to analysis of variance (ANOVA). Comparisons among diets means were carried out by Duncan Multiple Range Test (Duncan 1955) at a significant level of 0.05. All computation was performed using statistical package SPSS 15.0 (SPSS Inc., Chicago, IL, U.S.A).

III. RESULTS

Table 1 shows the percentage composition of the fermented and unfermented cassava peel meals respectively, while Table 2 shows the proximate compositions of the seven diets formulated for the feeding trial. The crude protein content of the diet ranged between 39.32 and 43.06%, crude lipid, 4.40-5.44% and crude fibre, 4.96-8.44%.

Table 1: The Proximate Composition (G/100g DM*) of Cassava Peels Used in Formulating the Experimental Diets

Parameter	Composition	
	Unfermented	Fermented
Crude protein	5.3	11.4
Lipid	1.2	3.5
Ash	5.9	6.3
Crude Fibre	20.9	7.1
Moisture	5.2	5.7
Carbohydrate	61.5	66.0

DM = dry matter

Table 2: The Proximate Composition of the Experimental Diets Fed to C. Gariepinus, During the Period of Study

			DIETS				
INGREDIENTS	D0	D20	D30	D40	D50	D60	D70
Crude protein	40.24	43.06	41.56	40.79	39.77	39.78	39.32
Moisture	9.96	7.31	8.13	7.76	7.08	7.13	8.25
Ether extract	5.17	5.08	5.41	5.44	4.55	4.57	4.40
Crude fiber	4.96	5.85	6.82	6.91	7.02	7.65	8.44
Ash	5.78	5.67	5.32	5.34	5.72	5.89	6.91
Nitrogen Free extract	33.89	33.03	32.76	33.76	35.86	34.98	32.68

NFE, Nitrogen free extract

Table 3 shows the hematological composition of fish fed with varying fermented cassava peel meal-based diet during the experiment. The Packed cell volume (PCV) results showed that the fish fed the control and D20 had increase in PCV values (32.00% and 30.00% respectively) when compared with the initial value. These values were not statistically significant (p>0.05) from one another. The fish fed diets D30 to D60 showed a decrease in the PCV. White blood cells (WBC) result showed that fishes fed D30 to D60 had higher values than fishes fed control and D20 diets. The highest value of 8.02 x 103 mm3 was recorded in fish fed diet D70.

The red blood cell (RBC) showed a decrease as fermented cassava peel meal increased in the diet. The fish fed control diet and D20 recorded values of 3.60×103 mm-3 and 3.20×103 mm-3 respectively and were not significantly different (P>0.05) from one another, but were significantly different from fish fed diet D30 to D60.

Hemoglobin (Hb) decreased in fishes fed diet containing D20 to D60. The fish fed the control diet and D20 recorded values of 9.20 g/100 ml and 9.00 g/100 ml respectively. These values showed a significant (P<0.05) difference from fishes fed diet containing D30 to D60.

Lymphocyte (LYMPH) count showed an increase as the level of CPLM increased in the diet. The highest value of 70.00% was recorded in fish fed diet D60 and D70 and the least value of 63.00% was recorded in fish fed the control diet. The highest value (30.77%) for MCHC was recorded in fish fed diet D30 and the lowest value (28.75%) was obtained in fish fed the control diet. The results obtained for MCH and MCV showed that the fishes fed diet D50 had the highest values of 47.00 pg and 160.00 fl for MCH and MCV respectively and the least values of 25.56 pg and 88.89 fl were recorded for MCH and MCV in fish fed D20 diet.

Table 4: Hematological Composition of Clarias Gariepinus Juveniles Fed With Varying Levels of Fermented Cassava Peel Meal-Based Diet

Parameter	D0	D20	D30	D40	D50	D60	D70
PCV %	27.80^{b}	32.00^{a}	30.00^{a}	27.00^{b}	27.50^{ab}	24.00^{c}	24.00^{c}
WBC (10^{3}mm-^{3})	7.20^{c}	7.45^{bc}	7.50^{bc}	7.60^{b}	7.60^{b}	8.00^{a}	8.02^{a}
RBC (10^{6}mm-^{3})	2.80^{b}	3.60^{a}	3.20^{a}	2.00^{b}	1.90^{b}	1.70^{b}	1.50^{bc}
Hb (g/100ml)	8.00^{b}	9.20^{a}	9.00^{a}	8.10^{b}	8.00^{b}	7.00^{c}	7.05^{b}
LYMPH (%)	60.00^{c}	63.00^{b}	63.02^{a}	64.00^{a}	64.05^{b}	70.00^{a}	70.00^{a}
MCHC (%)	28.78^{ab}	28.75^{ab}	29.00^{a}	29.02^{a}	29.00^{a}	30.17^{a}	30.38^{a}
MCH (pg)	28.57^{cd}	25.56^{d}	28.13^{cd}	40.50^{b}	42.11^{b}	36.84^{c}	47.00^{a}
MCV (fl)	100.00^{c}	88.89^{d}	93.75^{d}	93.00^{b}	92.84^{b}	133.33^{b}	160.00^{a}

Figures on the same row having the same superscript are not significantly different (p>0.05).

PVC = Packed cell volume; WBC = white blood cell; RBC = red blood cell; Hb = hemoglobin; LYMP = lymphocyte; MCHC=mean corpuscular hemoglobin concentration; MCH = mean

corpuscular hemoglobin; MCV=mean corpuscular volume.

Digestive enzyme assays in the gut of Clarias gariepinus (Table 3) indicated significant difference (P<0.05) between the gut amylase activity of the fish fed the control diet and the other dietary treatments, with D60 showing the least activity. Sucrase activity increased with increase in CPLM level, while maltase activity was not significantly different (P=0.05) from one another. The glucanase activity of the fish fed the various diets was not significantly different (P>0.05) from one another, but lower than the initial value. Cellulase activity decreased at lower CPLM level while there was no significant difference (P>0.05) at higher level of CPLM inclusion.

Table 5: Sugar Degrading Enzyme Activity From the Gut (G) of Catfish (Clarias Gariepinus)

Diet	Amylase	Sucrase	Maltase	Glucanase	Cellulase
Initial	36.64^{b}	4.51^{b}	4.23^{b}	4.23^{b}	1.83^{b}
Do	70.47^{a}	7.26^{a}	4.82^{b}	4.64^{a}	2.92^{a}
D20	66. 95a	5.17^{c}	5.07^{a}	4.65^{a}	2.58^{a}
D30	42.58^{a}	12.47^{a}	4.59^{a}	4.19^{a}	1.76^{ab}
D40	41.58^{a}	10. 86^{a}	4. 52^{a}	4. 19^{a}	2.04^{ab}
D50	37.53^{a}	14. 29^{a}	4. 86^{ab}	3. 34^{a}	1.56^{ab}
D60	36.57^{b}	14.22^{a}	4.77^{ac}	1.01^{a}	1.00^{bc}
D70	33.54^{b}	15.12^{a}	5.01^{ac}	1.32^{a}	1.57^{bc}

Note: Samples with the same letter in a column are not significantly different at 5% level

IV. DISCUSSION

The potential of a feedstuff such as cassava peel and leaf meal in fish diets can be evaluated on the basis of its proximate chemical composition, which comprises the moisture content, crude protein, crude fibre, crude fat, total ash, carbohydrate and nitrogen free extract. The proximate composition of fermented cassava peel meal in the present investigation revealed that the crude protein content was 28.03%, crude fibre 18.87%, crude fat 2.25%, carbohydrate 48.00 and total ash 6.81%. These values as observed in this study fell within the range obtained by Sotolu, (2010). This confirmed the potential of fermented cassava peel meal as adequate animal feedstuff from nutritional point of view. A trial conducted by Oboh and Akindaunsi (2003) on the fermentation of cassava peels with a consortium of microorganism indicated a significant increase in protein content and digestibility of the microbially treated peels, as against the untreated control. The authors concluded that such fermented cassava by–product could be a good supplement in compounding animal feed.

Antai and Mbongo (1994) observed that fermentation of cassava peels by pure culture of Saccharomyces cerevisiae could increase its protein content from 2.4% in non-fermented cassava to 14.1% in fermented products. They reported that fermented cassava flour, with S. cerevisiae, enhanced the protein level (from 4.4% to 10.9%) and decreased the amount of cyanide content (Oboh and Akindahunsi, 2005).

Noomhorm et al. (1992) reported that the conversion of a part of the starch in cassava root meal to protein by microbes, during the process of solid-state fermentation, has great potential as a means of improving the feed value of cassava root meal. As observed in this work, Adeyemi and Sipe (2004) also reported an improvement in crude protein concentration of cassava root when fermented with rumen filtrate with or without ammonium sulphate as the source of nitrogen.

Adeyemi et al. (2004) obtained a value of 237.8 % increase in the crude protein value of whole cassava root meal fermented with rumen filtrate using caged layer waste as source of nitrogen. Ubalua and Ezeronye (2008) have identified fermentation as one of the less expensive means of increasing the protein quality of cassava and cassava wastes. Dried products from roots, which have been fermented or ensiled to detoxify the

HCN or to increase their protein content, are other ways of root processing (Khajarern and Khajarern, 2007).

All the haematological parameters measured in this study were within the recommended physiological ranges reported for C. gariepinus. The change in the blood characteristics of C. gariepinus caused by stress due to exposure to environmental pollutants, diseases or by pathogens have been studied by a number of workers especially in capture fisheries (Onusiriku and Ufodike, 2000; Ezeri, 2001; Gabriel et al., 2001).

Blaxhall and Daisley (1973) reported the essence of using haematocrit to detect anaemic condition in fishes. The packed cell volume (PCV) range 24.00 to 32.00% observed in this study is within the range of 20 to 50% reported by Pietse et al. (1981), though, a decrease was observed in the level of PCV as the level of CPLM increased in the diet. Reduction in the concentration of the PCV in the blood usually suggests the presence of toxic factor. The decreasing trend observed in the PCV of this study may be attributed to the presence of remnants of some anti-nutrients, such as some levels of hydrogen cyanide, tannin and mimosine in the fermented cassava peel meal as reported by Oboh and Akindahunsi (2003).

White blood cells (WBC) and lymphocytes results recorded in this study showed an increase as the level of CPLM increased in the diet. White blood cells (WBC) and lymphocytes are the defence cells of the body. Douglas and Jane (2010) demonstrated that the amount has implication in immune responses and the ability of the animal to fight infection. High WBC count is usually associated with microbial infection in the circulatory system (Oyawoye and Ogunkunle, 1998). The value range of 7.20 × 103 to 8.02 × 103 mm-3 recorded in this study for WBC was lower compared to 16.13 × 103 to 16.39 × 103 mm-3 reported by Sotolu and Faturoti (2009).

Reduction in the red blood cells was observed as the level of fermented cassava peel meal increased in the diet. The range of RBC (1.50 ×106 to 3.60 ×106 mm-3) recorded in this study is fairly comparable with (1.70 × 106to 4.00 × 106 mm-3) reported by Bhasker and Rao (1990) and lesser than (2.24 × 106 to 2.49 × 106 mm-3) reported by Sotolu and Faturoti (2009). The decrease in RBC could probably be due to the high concentration of anti-metabolites in the diet containing more fermented cassava peel meal.

The haemoglobin result showed a decrease as the CPLM increased in the diet. The haemoglobin range (7.00 – 9.20g/100ml) recorded were high and fell within the range (5.6 to 15.8 g/100 ml) reported for Esox lucius (Mulcahy, 1970). It also compared well with (8.70 g/100 ml) recorded for C. gariepinus (Sowunmi, 2003). These values were also higher than 4.46 g/100 ml reported for Heterotis niloticus (Fagbenro et al., 2000). The range of haemoglobin concentration recorded in this study is quite high and can be related to large anaerobic metabolism capacity of C. gariepinus. The decrease in the level of haemoglobin as CPLM increased in the diet could imply that diets having higher fermented cassava peel meal had negative effect on the blood.

The mean corpuscular volume (MCV) range (88.89 to 160.00 fl) recorded in this experiment was higher than (79.20 to 105.32fl) reported for Heteroclarias by Anyanwu et al. (2011), meanwhile the mean corpuscular haemoglobin concentration (MCHC) range (28.75 to 30.77%) recorded in this study compared fairly well with 30.70% reported for C. gariepinus from Asejire dam (Adedeji and Adegbile, 2011).

The MCH results showed that the fish fed diet D50 recorded the highest values. The MCH range (25.56 to 47.00 pg) obtained in this study was higher than the range (20.82 to 26.60 pg) reported for Heteroclarias fed Carica papaya leaf meal incorporated feed (Anyanwu et al., 2011). In recent years, good management practices have been advocated as effective ways of reducing stress in fish culture (Gabriel et al., 2007).

The enzymes present in the gut of the fish fed experimental diets were lower compared to the initial. The decreasing amylase activities in the fish, as the level of CPLM increases in the diets, can be explained by lower dietary lipid levels. As

reported here, Fountoulaki et al. (2005) also reported that in gilthead sea bream, amylase is affected by dietary fat level. Apata and Ojo (2000) suggested that the decrease in the effect of enzymes in the gut may be due to the change arising from the breaking down of high dietary fibre. Clarias gariepinus is physiologically equipped to cope with frequently and irregular meals as its digestive enzymes respond faster to feeding than those of eel (Anguilla anguilla) or carp (Cyprinus carpio) (Yalcin et al., 2001; Adeyemi et al., 2004).

From the above observations, it is evident that maize substitution with fermented cassava peel meal at a rate of up to 50% in catfish (C. gariepinus) fish feed have no adverse toxicological effect on the fish as revealed through the haematological indices and digestive enzyme assay. Essers et al., (1995) documented that 50% replacement of maize with cassava meal in broiler diet showed no depression in growth or unfavourable feed conversion ratio. This was also supported by Olurin et al. (2006) who reported a replacement level of 50% cassava meal for maize without a depressing growth in Clarias gariepinus.

V. CONCLUSION

These investigations have revealed that up to 50% substitution rate of fermented cassava peel meal for fishmeal in catfish (C. gariepinus) fish feed produces no adverse toxicological effect on the fish as revealed through the haematological and digestive enzyme indices. By fermentation method, fish feed can therefore be produced at relatively cheaper cost by the use of commonly available cassava peels thus increasing the profits to fish farmers.

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ABSTRACT

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Classification: FOR Code: 280212

Language: English

London Journals Press

LJP Copyright ID: 925652
Print ISSN: 2631-8490
Online ISSN: 2631-8504

London Journal of Research in Science: Natural and Formal

Volume 22 | Issue 15 | Compilation 1.0

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A time series is a predetermination of data points that happen in repeated order of time. Forecasting productions play a necessary part in several fields such as, meteorological data, weather data, stock market data, rainfall data, agriculture data and so on. In recent years, fuzzy time series is used for forecasting. Song and Chissom (1993) proposed fuzzy time series for forecasting enrollments of data. In this paper, Autoregressive Integrated Moving Average Model (ARIMA), Neural networks for Radial Basis Function (RBF) and Multilayer Perceptran(MLP) and fuzzy time series for predicting wheat production of India were compared. Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE) and Root Mean Square Error (RMSE) were compared. The results were displayed numerically and graphically.

Keywords: ARIMA, neural network, fuzzy time series, MAE, MAPE, RMSE, residual analysis and prediction.

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I. INTRODUCTION

The time series is a category of variables ordered in a specific order of time. Forecasting believes the future values of the time series. For the past decades, fuzzy time series has been widely used for predicting the historic data. Fuzzy time series is used to planning with forecasting difficulties in which the historical data are linguistic values. Song and Chissom (1993) proposed the fuzzy time series for the enrollments of university of Alabama. Wheat is the chief cereal crop in India. Wheat crop has well-known flexibility. Wheat is developed in a variety of soils of India. Yanpeng Zhang et.al(2020) proposed a novel fuzzy time series forecasting model by multiple linear regression and time series clustering for forecasting market prices. Singh, P. (2018) offered a new model to deal with four major issues of fuzzy time series (FTS) forecasting, viz., Wangren Qiu et.al(2015) proposed model was implemented in forecasting enrollment data at the University of Alabama. Ozge Cagcag Yolcu et.al(2016) proposed a novel high-order fuzzy time series approach that considers the membership values, where artificial neural networks are employed to identify the fuzzy relations. Adesh Kumar Pandey(2008) proposed fuzzy time series and neural network. The proposed method has been implemented in the historical data. Paarth Thadani(2021) presented non-linear forecasting models, including artificial neural networks, are popularly adopted in financial forecasting. Yousif Alyousifi et.al (2021) proposed Fuzzy Time Series Markov Chain – Transition Probability Matrix model is tested using two types of time series data, namely, air pollution index (API) data, and yearly enrollments for the University of Alabama.Wang et.al (2017) applied autoregressive integrated moving average model and artificial neural network for air pollution data. Alyousi et. al (2019) applied artificial neural network and Markov chain are applied for air pollution forecasting. In this work, ARIMA, Neural networks for Multilayer Perceptron and Radial Basics Function and fuzzy time series algorithms are used for wheat production prediction in India. Residual analysis for Mean

Absolute Error (MAE), Mean Absolute Percentage Error (MAPE) and Root Mean Square Error (RMSE) were compared.

II. METHODOLOGY

2.1 Autoregressive Integrated Moving Average Model

Autoregressive Integrated Moving Average Model (p, d, q), where p is Autoregressive and q is the Moving Average Model and d is the differencing. If d =0, the data exhibits stationary and the order is denoted as (p, q), which is called ARMA process. If the data does not exhibit stationary, the first order differencing is carried out in converting it into a stationary, hence the model is denoted as (p, d, q).

2.2 Radial Basis Function (RBF)

RBF networks, a class of feed forward networks, called radial basis function that compute activations at the hidden neurons in a way that is different from what we have seen in the case of feed forward neural networks. Rather than employing an inner product between the input vector and the weight vector The RBF output layer results in a linear fashion. The output y is computed by

$$y_i(x) = \sum_{k=1}^{J_2} W_{ki}\phi\left(\|X - C_k\|\right)$$

For i= 1,.., J_3 where $y_i(x)$ is the i^{th} output of the RBF. W_{ki} is the connection weight from the k^{th} hidden to the i^{th} output unit C_k is the prototype or center of the kth hidden unit, and $\|.\|$ denotes the Euclidean norms. The RBF ϕ(.)typically selected as the Gaussian function

$$\phi(x - c_i) = e^{-\|x-c_i\|^2/2\sigma^2}$$

Where $c_i = (c_{i1},c_{i2},\ldots,c_{in})$ is the center of the associated field, and σ is the width of the Gaussian function.

2.3 Multi Layer Perceptron

Artificial Neural Network(ANN) is an operational model which consists of a large number of interconnected nodes(neurons). Each node contains a specific output function which is called an activation function. The connection between every two nodes represents a weighted value that passes through the connection signal, which is called weight. Weight is equivalent to the memory of ANN. Multi Layer Perceptron(MLP) has many layers, the first layer is the input layer, the last layer is the output layer, the middle layers are called hidden layers, each layer includes several neurons. This calculation process is called feed forward process of MLP. If there is an MLP, which contains m hidden layers, its input and output dimensions are respectively equal to n_1 and n_{m+2}. The number of nodes in each hidden layer is $n_2,n_3,\ldots,n_{m+1}$ respectively. In the feed forward process of this MLP, each node value is calculated using the following formula

$$X_{ij} = f(WX_{i-1}+b_{i-1})$$

fis the activation function.

Where X_{ij} represents the value of the j neuron i layer. W_i represents the weight vector of the j neuron in layer i-1 to layer i. X_{i-1} represents the value vector of all neurons in layer i-1. b_{i-1} represents the bias of the i-1 layer , and f is the activation function.

2.4 Fuzzy Time Series

It is the values of the observations of a special dynamic process are represented by linguistic values.

Computational Algorithm for Fuzzy Time Series

The step by step process is as follows:

Step1: Calculate the first order variation of the historical data.

Step2: Define the universe of discourse, U based on the range of available historical data.

$$U=[D_{min}-D_1, D_{max}+D_2]$$

Where D_{min} is the minimum value of the first order variation of the historical data,D_{max} is the maximum value of the historical data and D_1, D_2 are two positive integers.

Step3: Partition the universe of discourse U into equal length intervals: $u_1,u_2,\ldots,u_m$.

Step4: The number of intervals will be in accordance with the number of linguistic variables (fuzzy sets) $A_1,A_2,\ldots,A_m$ to be considered.

Step5: Fuzzify the variations of the historical data and establish the fuzzy logical relationship is represented by $A_i \rightarrow A_j$.

Step6: Rules for forecasting:

$[A_j]$ is corresponding interval u_j for which membership in A_j is supremum (i.e., 1)

$L[A_j]$ is the highest value of the interval u_j having supremum value in A_j.

$M[A_j]$ is the mid value of the interval u_j having supremum value in A_j.

For a fuzzy logical relationship $A_i \rightarrow A_j$.

A_i is the fuzzified wheat production of the current year n;

A_j is the fuzzified wheat production of the next year n+1;

D_i is the actual wheat production of the current year n;

D_{i-1} is the actual wheat production of the previous year n-1;

E_i is the variation wheat production of the current year n;

E_{i-1} is the variation wheat production of the previous year n-1;

F_j is the forecasted wheat production of the next year n+1;

Step7: Forecasting wheat production for the year n+1 is obtained from modified computational algorithm as follows;

Obtain the fuzzy logical relationship $A_i \rightarrow A_j$.

$$\text{If } E_i < M[A_j], \text{ then } F_j = D_{i-1} + (M[A_j] - 1/6L[A_j])$$
$$\text{elseIf } E_i > M[A_j], \text{ then } F_j = D_{i-1} + (M[A_j] + 1/6L[A_j])$$
$$\text{else } F_j = D_{i-1} + M[A_j]$$

Step8: Obtain the mean absolute error using actual values and forecasted values

$$MAE = \frac{1}{n}\sum_{t=1}^{n}|u_t|$$

Where n is the number of years and $|u_t| = Y_t - \hat{Y}_t$. Y_t is actual values at time t. $\hat{Y}_t$ is predicted values at time t.

Step9: Obtain the mean absolute percentage error using actual values and forecasted values

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}\left|\frac{Y_t - \hat{Y}_t}{Y_t}\right|$$

Step 10: Obtain the root mean square error using actual values and forecasted values

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}\left(Y_t - \hat{Y}_t\right)^2}{n}}$$

III. RESULTS AND DISCUSSIONS

Step1: Compute the first order variation of the historical data.

Step2: The universe of discourse U is defined as+

$$U=[D_{min}-D_1, D_{max}+D_2]$$

$$U=[-9323-77, 11510+90]= [-9400, 11600]$$

Where D_{min}= -9400 is the minimum value of the first order variation of the historical data.

D_{max}= 11600 is the maximum value of the first order variation of the historical data,
D_1=77 and D_2=90 are two positive integers. D_1, D_2 are choosing arbitrarily for the rounded off U value.

Step3: The universe of discourse U is partitioned into five equal length of intervals.

U_1=[-9400, -5200] U_2= [-5200, -1000] U_3= [-1000, 3200] U_4 = [3200, 7400] U_5 =[7400, 11600]

Step4: Define five fuzzy sets $A_1, A_2, \ldots, A_8$ having some linguistic values on the universe of discourse U. The linguistic values are as follows:

A_1= very poor A_2= poor A_3= Moderate A_4= Good A_5= Very Good

Table 1: Fuzzified Wheat Production(tonnes) on Variations

Year	wheat production(tonnes)	Variations	Fuzzified variations
2001	69681	-	-
2002	72766	3085	A3
2003	65761	-7005	A1
2004	72156	6395	A4
2005	68637	-3519	A2
2006	69355	718	A3
2007	75807	6452	A4
2008	78570	2763	A3
2009	80679	2109	A3

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2010	80804	125	A3
2011	86874	6070	A4
2012	94882	8008	A5
2013	93506	-1376	A2
2014	95850	2344	A3
2015	86527	-9323	A1
2016	87000	473	A3
2017	98510	11510	A5
2018	99870	1360	A3
2019	103600	3730	A4
2020	107860	4260	A4
2021	109520	1660	A3

Step5: The membership of above mentioned linguistic variables is assigned through the Trapezoidal membership function by fixing the values arbitrarily. The memberships of Linguistic variables are as follows.

$$A_1 = 1/u_1 + 0.5/u_2 + 0/u_3 + 0/u_4 + 0/u_5$$
$$A_2 = 0.5/u_1 + 1/u_2 + 0.5/u_3 + 0/u_4 + 0/u_5$$
$$A_3 = 0/u_1 + 0.5/u_2 + 1/u_3 + 0.5/u_4 + 0/u_5$$
$$A_4 = 0/u_1 + 0/u_2 + 0.5/u_3 + 1/u_4 + 0.5/u_5$$
$$A_5 = 0/u_1 + 0/u_2 + 0/u_3 + 0.5/u_4 + 1/u_5$$

Step6: The historical variations of the time series data are fuzzified in order to have the fuzzy logical relations obtained as follows: Variations in the fuzzy logic relationships

$$A_3 \rightarrow A_1,\ A_1 \rightarrow A_4,\ A_4 \rightarrow A_2,\ A_2 \rightarrow A_3,\ A_3 \rightarrow A_4,\ A_4 \rightarrow A_3$$
$$A_3 \rightarrow A_3,\ A_3 \rightarrow A_3,\ A_3 \rightarrow A_4,\ A_4 \rightarrow A_5,\ A_5 \rightarrow A_2,\ A_2 \rightarrow A_3$$
$$A_3 \rightarrow A_1,\ A_1 \rightarrow A_3,\ A_3 \rightarrow A_5,\ A_5 \rightarrow A_3,\ A_3 \rightarrow A_4,\ A_4 \rightarrow A_4$$
$$A_4 \rightarrow A_3$$

Step-7: The forecasted values have been obtained by using the computational algorithm. Then the forecasted output while comparing with different models given as table 2.

Table 2: Forecasted Wheat Production(tonnes) by Different Models

Year	Actual Wheat Production	ARIMA	RBF	MLP	Fuzzy Time Series
2001	69681	70444	71136	68012	---
2002	72766	72919	70476	68511	71314
2003	65761	69333	68013	69209	66333
2004	72156	72296	67256	70171	72294
2005	68637	71247	67285	71465	69223
2006	69355	71458	69203	73150	69204
2007	75807	75788	76098	75258	74655

2008	78570	79249	78514	77761	77440
2009	80679	81977	79655	80561	80203
2010	80804	83173	82161	83488	81246
2011	86874	87615	86382	86339	87337
2012	94882	94466	90346	88932	94441
2013	93506	96192	93535	91147	91949
2014	95850	98445	91769	92941	95139
2015	86527	93432	85975	94331	87683
2016	87000	92056	87682	95372	87094
2017	98510	99045	98117	96132	98433
2018	99870	102568	100114	96676	100143
2019	103600	106355	104423	97061	103937
2020	107860	110576	108673	97331	107667
2021	109520	113292	108709	97518	109493

Table 2 shows that wheat production of actual values and forecasted values using different models, namely, ARIMA, RBF,MLP and fuzzy time series.

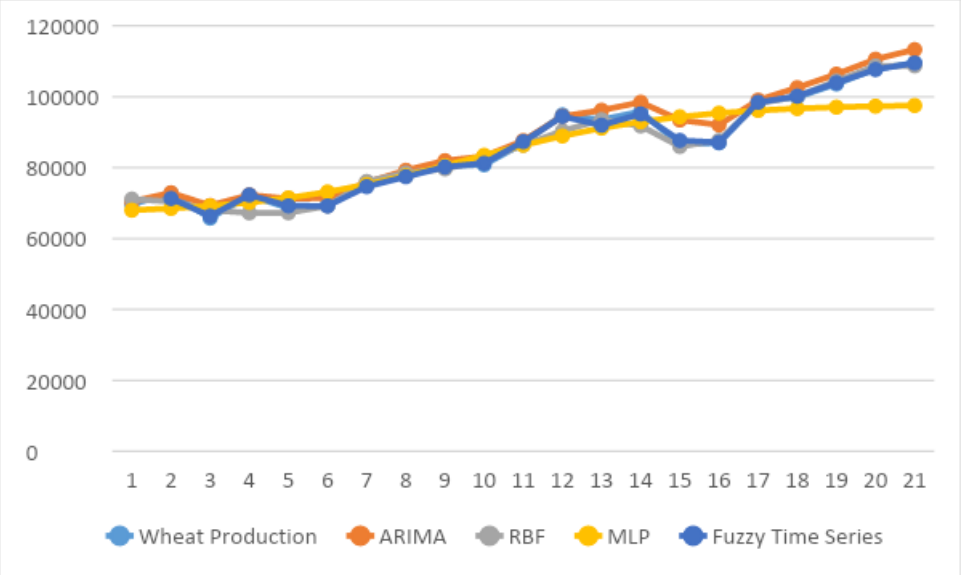

Figure 1 Shows that actual and forecasted values of wheat production of various models were compared by using line chart.

Figure 1: Actual and Forecasted Values of Wheat Production (tonnes)

Table 3: Residual Analysis by Different Models

Models	MAE	MAPE	RMSE
ARIMA	3453.9	4.188	4907.1
RBF	1361.19	1.668	1972.72
MLP	4033.857	4.5134	5171.001
Fuzzy Time Series	571.4	0.6976	733.569

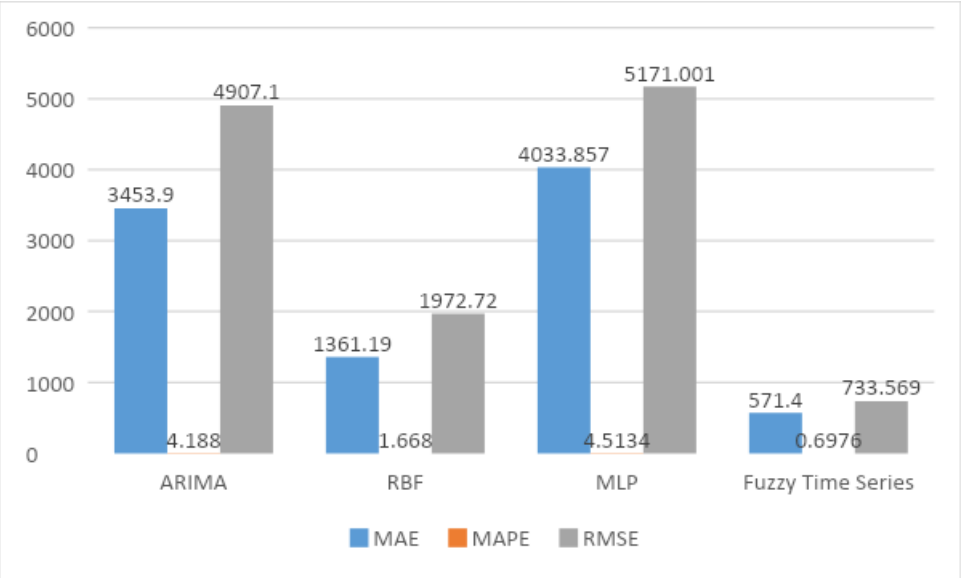

Figure 2: Residual Analysis by Using ARIMA, RBF, MLP and Fuzzy Time Series

Figure 2 shows that the mean absolute error, mean absolute percentage error and root mean square error obtained by using ARIMA and neural networks for Radial Basics Function and Multilayer Perceptron and fuzzy time series for wheat production prediction. Mean absolute error, mean absolute percentage error and root mean square error of fuzzy time series is less values when compared to ARIMA and neural networks. Mean absolute error, mean absolute percentage error and root mean square error show that the performance of fuzzy time series is better than that of ARIMA and neural networks.

III. CONCLUSION

In this work, three models, namely ARIMA, neural networks and fuzzy time series were used for wheat production prediction in India. Residual analysis for mean absolute error, mean absolute percentage error and root mean square error were compared using bar charts. Mean absolute error, mean absolute percentage error and root mean square error were minimum for fuzzy time series when compared to ARIMA and neural networks. Fuzzy time series is performed better than that of ARIMA and neural networks.

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Studies on the Effect of Edible Coatings on the Quality Attributes of Guava Fruit

Sudhir Pratap & Kawaljeet kaur

ABSTRACT

Guava is one of the most important fruit crops of India. It was originated in tropical America. It covers around 3.3% of the total area under fruit crops and contributes 3.3% of the total frit production in India. In India, Uttar Pradesh leads in production, while Allahabad region of U.P produces best quality of guava in India as well as in the world. Guava is rich source of ascorbic acid. It is good source of dietary fiber and pectin. It can be processed into a number of products like jam, jelly, nectar, juice, guava cake, Puree etc. Its roots, bark, leaves and fruits has great medicinal value.

The perishability of fresh produce during the postharvest period, before it reaches the market, is a leading cause for the food scarcity across the globe. The prevention of microbial attack and maintenance of the hydrodynamic potential as brought about through the edible coating can be an effective solution to manage the same. Although edible coatings have already been exploited over a century to expand the shelf life and freshness of the fresh produce, engineering the edible coating through the incorporation of antimicrobial agents and nanomaterials can widen its scope and application. Various bioderived substances like lipids, hydrocolloids, and their combinations have recently been used as the film forming solution to obtain tailor made properties including transparency, texture, moisture and oxygen barrier and microbial barrier properties for exploiting their applications as edible coatings. These coatings can ensure the extended shelf life, prevent the microbial load, and can also act as a nutrient fortifier depending upon the active component employed.

Keywords: NA

Classification: FOR Code:030499

Language: English

London Journals Press

LJP Copyright ID: 925653
Print ISSN: 2631-8490
Online ISSN: 2631-8504

London Journal of Research in Science: Natural and Formal

Volume 22 | Issue 15 Compilation 1.0

Studies on the Effect of Edible Coatings on the Quality Attributes of Guava Fruit

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ABSTRACT

Guava is one of the most important fruit crops of India. It was originated in tropical America. It covers around 3.3% of the total area under fruit crops and contributes 3.3% of the total frit production in India. In India, Uttar Pradesh leads in production, while Allahabad region of U.P produces best quality of guava in India as well as in the world. Guava is rich source of ascorbic acid. It is good source of dietary fiber and pectin. It can be processed into a number of products like jam, jelly, nectar, juice, guava cake, Puree etc. Its roots, bark, leaves and fruits has great medicinal value.

The perishability of fresh produce during the postharvest period, before it reaches the market, is a leading cause for the food scarcity across the globe. The prevention of microbial attack and maintenance of the hydrodynamic potential as brought about through the edible coating can be an effective solution to manage the same. Although edible coatings have already been exploited over a century to expand the shelf life and freshness of the fresh produce, engineering the edible coating through the incorporation of antimicrobial agents and nanomaterials can widen its scope and application. Various bioderived substances like lipids, hydrocolloids, and their combinations have recently been used as the film forming solution to obtain tailor made properties including transparency, texture, moisture and oxygen barrier and microbial barrier properties for exploiting their applications as edible coatings. These coatings can ensure the extended shelf life, prevent the microbial load, and can also act as a nutrient fortifier depending upon the active component employed.

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I. INTRODUCTION

Guava (*Psidium guajava* L.) is a tropical fruit belonging to family Myrtaceae. Chromosome number is 2*n* = 22. Under this genus, more than 5000 species are present. Guava is commonly known as ‗Apple of Tropics'. Tropical America is considered as the origin of guava. During 17th century, it was introduced in India and at present it is widely cultivated on commercial scale (Menzel, 1985). It has been reported that Indo-Gangatic plains have much genetic diversity of guava (Rajan *et al.*, 2007).

According to the report of Anonymous (2018), India is the leading guava producing country, which is followed by its neighboring countries China, Pakistan and Indonesia. In India, the total area under guava cultivation is 2, 65 thousand hectares (ha.) with annual production of 4054 thousand metric tonnes (MT) and productivity 15.29 MT/ha. It occupies 4th position in terms of total area covered by fruit crops. The leading state in production of guava fruit is U.P which is followed by M.P and Bihar. Number of varieties is commercially cultivated in India. Some of the most popular and widely grown varieties are Sardar guava, Shweta, Allahabad Safeda, Arka Mridula, Chittidar, Lalit, and Pant Prabhat.

Guava is also the important crop of Punjab and ranks second after citrus. It grows well in almost all the districts of the state covering an area of 2.5 lakh ha. yielding 195.60 thousand MT accounted for 3.97% of area and 4.42 % of production. The average productivity of guava is now 15.9 MT/ha (Anonymous, 2018).

London Journal of Research in Science: Natural and Formal

Guava is well adapted to various ecological conditions which also include the wastelands and soils with high range of pH value (8.6 to 9.6). Guava tree requires minimum care and give high economic returns because of its highly productive nature, toughness and adaptability. The fruits of guava can be eaten as raw and also can be used for processing products like jam, juice, nectar wine and fruit leather. (Jaiswal and Amin, 1992).

Guava is one of the nutritious fruit. Each 100gm guava contain 228.3 mg Vitamin C, 80.80g Water, 68kcal Energy, 2.55g Protein, 0.95g Total lipid (fat), 14.32g Carbohydrate,5.4g Fiber,8.92g Sugars,18mg Calcium, 0.26mg Iron, 22mg Magnesium, 40mg Phosphorus, 417mg Potassium, 2mg Sodium, 0.23mg Zinc, etc. (Singh, 2005).

Under ambient conditions, the shelf life of guava is about 3-4 days. The fruit is climacteric in nature. Thin exocarp layer that makes it hard for the fruit to retain moisture. Research on guava has led to the development of some promising varieties which are good on size and nutrition but still post-harvest storage under ambient conditions is a challenge for most of the food technologists and researchers. Of the various methods, to increase the storage life of fruits, edible coating is in practice. It prolongs the storability and keeping quality of fruits. Coatings act as a barrier between fruit and external environment, which further leads to improve the storage of fruits under cold conditions and ambient condition.

Exogenous application of chemicals such as chitosan, $CaCl_2$, polyamines and gibberellins are being used to retard the physiological changes of the produce so as to increase the shelf-life. Chitosan is a high molecular weight cationic polysaccharide. It is made up of glucosamine and N-acetylglucosamine with a β-1-4 glycosidic linkage (Hadwiger and McBride, 2006). Chitosan is biodegradable and, exhibits excellent biocompatibility, non-toxicity and antioxidant property (Zhelyazkov *et al.*, 2014; Hussein *et al.*, 2015). Chitosan application on fruit surface act as a barrier (Elsabee and Abdou, 2013), which makes it potential for coating. It acts as an excellent semi- permeable barrier against the exchangeable gases like oxygen and carbon dioxide. It also minimizes the loss of moisture, thus which reduces the rate of respiration and water loss, which reduces the shrinkage of fruits (Velickova *et al.*, 2013; Petriccione *et al.*, 2015) hence retarding ripening and senescence. Structure of membrane and cell wall is enriched with the calcium ions (Oms-Oliu *et al.*, 2010). Calcium (Ca) delays the process of ripening particularly the softening and hence, increases the shelf-life by altering intercellular and extracellular processes (Shehata *et al.*, 2009).

Various researchers have tried different coating materials on different fruit crops such as *Aloe vera*, guar gum, chitosan, bee wax, petroleum jelly, corn starch, neem extract, citric acid, cellulose, calcium chloride, pectin, olive oil, xanthan gum, carnauba wax, soy protein, sorbitol, coconut etc. and various packaging materials like LDPE, HDPE, PP, cling film, shrink film etc. which yielded positive outcomes in enhancing storability of various fruits. Edible coating is beneficial in order to maximize the life of fruits & delay the ripening in guava fruit (Wijewardane and Guleria, 2009).

Hypothesis for research

i. Edible coating and packaging material may increase the shelf life of guava.
ii. Edible coating and packaging material may have beneficial effect on the quality parameters of guava.

II. REVIEW FINDINGS

A good proportion of literature is available regarding use of coating and packaging materials for shelf life and quality enhancement of fruit crops. Various researchers have contributed to the field of post-harvest shelf life extension of fruits using various coating and packaging materials. A comprehensive review of literature is mentioned below:

Effect of coating materials on physical and chemical attributes of fruits:

Ochoa-Reyes et al., (2019) conducted study on use of edible coating formulation for improvement of shelf-life quality of green sweet peppers by using 3 biopolymers like pectin, Xanthum gum & Arabic gum in combinations with Candelilla wax and jojoba oil, hydrophobic phase by way of plasticizer and crude extract of polyphenols as basis of bioactive compounds. All treated green sweet peppers were found significantly different in weight loss when compared to control. Although slow rate of decline was found in fruit coated with arabic gum, however visual form remained same amongst fruits treated with various different coatings.

Adiletta et al., (2018) performed an experiment by coating chitosan over loquat at 7°C for 21 days. They found the improved activity of enzyme catalase, superoxide, dismutase, ascorbate and peroxidase. Also fruit membrane integrity was maintained by chitosan.

Baraiya et al., (2018) studied the complex coating acts as a base of antioxidants and increases the quality & post-harvest shelf life of table grapes. In Thompson seedless, 0.1ml olive oil in 100ml and 0.3ml xanthan gum in 100ml was used and achieved better result with olive oil incorporated + xanthan gum with gallic acid which increases the quality and postharvest storage lifespan of grapes.

Hassanein et al., (2018) conducted experiment on gamma irradiation along with coating of guava fruit with calcium chloride and lemon grass and monitor the growth of fungus and fruit quality during cold storage and concluded that calcium chloride and lemongrass strongly inhibit physiological activity and fungal growth in guava fruit under cold storage conditions.

Lopez-Palestina et al., (2018) evaluated the effect of coating treatment with tomato oil extract on antioxidant and physicochemical properties of grambullo and observed that there was upsurge in antioxidant activity up to 5 days after coating whereas there was reduction recorded on 10th and 15th day with no significant difference.

Mandal et al., (2018) explained the impact of coating (edible) application on postharvest quality and storage life of mango, in which they informed that throughout the storage period, TSS increase and Titrable acidity decrease in fruits. Therefore TSS/ acid were increased due to more moisture loss from fruit. More utilization of acid and increased respiration might be lead to depletion of organic acids.

Romani et al., (2018) studied the effect of starch coating incorporated with pink pepper phenolic compounds on apple and advocated that the coating was helpful in lowering enzymatic browning in apples by inhibiting the enzyme peroxidase.

Sapper and Chiralt (2018) evaluated the preservation of vegetables and fruits by using starch based coatings in which they concluded that edible coatings are another method of preservation of fruits and vegetables or preservation technology which change the gas composition of fruits by generating a modified environment or barrier between the internal and external atmosphere gaseous exchange like oxygen, carbon dioxide and volatiles and also reduce water transfer.

Sucharitha et al., (2018) studied the influence of chitosan coating on storage strength of tomatoes in which they coated tomatoes with 0.25% and 0.5% chitosan. The microbial load and physic-chemical parameters were calculated for 30 days and found that lower 0.25% concentration was more effective than 0.5% chitosan treatment and control in terms of pH, TSS, Titrable acidity, Vitamin C (ascorbic acid), weight loss, moisture percent and also reduces microbial growth.

Abdi et al., (2017) observed the coating influence of pectin comprising of essential oils for enhancing the appearance of strawberry in which orange and lemon peel oil along with pectin. Outcomes revealed that pectin + lemon's essential oil has good impact on quality of fruit and visual form as compare to chief free pectin treatment and orange essential oil which increase shelf-life of strawberry 12 days more as compare to control. *Abebe et al., (2017)* observed the effect of edible

coating material and stages of maturity at harvest on quality and storage life of tomatoes with pectin and chitosan and investigation was done on different harvesting phases of fruit which was matured green, red & light red and observed that treatments delays the ripening process of fruits as compare to uncoated fruits. Results showed that maximum shelf-life of 17 days achieve in turning stage which were coated with pectin, 15 days shelf-life observed in chitosan and 10 days shelf life in control.

Jain et al., (2017) studied the influence of various edible coatings & chemical in which they use GA_3 @ 40 ppm, Aloe vera gel, $CaCl_2$ @1%, Almond oil and Olive oil for treatment and kept under cold storage (3-5° C and 85-95 Relative humidity) and ambient conditions. The results showed that fruits coated with $CaCl_2$ @1% at cold storage conditions expand 30 days life period of fruit as comparison to control which is 9 days at ambient situations.

Jawandha et al., (2017) reported the effect of *Aloevera* gel, chitosan & carboxymethyl cellulose over Punjab Beauty pear and found out that the palatable quality of fruit was best till 67 days after harvesting but after 74 days the quality was poorly degraded.

Krasniewska et al., (2017) determined the effect of pullulan treatment on quality and post-harvest shelf-life of high bush blueberry and concluded that those fruits coated with pullulan coating were more protected as compare to uncoated fruits and fruits decrease less weight, slower rate of change in sugars content that maybe the effect of diminishing in the degree of transpiration & respiration which also retains the attractiveness and freshness of fruits.

Mani et al., (2017) observed the influence of various coating of *Aloe vera* on physiology and quality of ber under ambient conditions in which they use 1% corn starch, 2% *Aloe vera* gel and study revealed that fruit coated with *Aloe vera* gel were more efficient in maintaining better quality of fruits in a storage period of 15 days. *Aloe vera* treated fruit showed less weight loss, lowest shrinkage percentage, and slower rate of reducing and total sugar development due to ripening.

Singh et al., (2017) studied the effect of oil coatings to enhance the quality and shelf life of guava fruit in which they used almond oil, mustard oil, grape seed oil, olive oil & coconut oil at ambient condition and cold storage. Investigation showed that shelf- life extended significantly those fruits coated were with olive oil at room temperature up to 16 days and for 28 days in controlled storage and those fruits which were coated with mustard oil showed minimum physiological weight loss when comparing with other treatments.

Ullah et al., (2017) observed the effect of different coatings on bio-chemical traits of fruits and storability of bell pepper fruit in which they observed that coating with *Aloe vera* gel, gum Arabic and cinnamon oil, the storage life was enhanced and quality of sweet pepper fruit for longer time period was maintained as compared to control treatment. Sweet pepper treated with gum Arabic (12%) significantly decreased ascorbic acid, total soluble sugars, membrane leakage, decay development, weight loss, TA, sugars and pH of fruit. So they suggested 12% gum Arabic may possibly a potential coating for sustaining postharvest value and increasing storage life period of fruit.

Yimenu et al., (2017) investigated the effect of linseed oil and bee wax coatings and frequency of dipping on the organoleptic and biochemical quality of orange juice andobserved that fruits treated with three layer bee wax emulsion showed better results as compare to linseed oil and untreated fruits.

Ali et al., (2016) studied the influence of *Aloe vera* gel (0%, 10%, 20%, 30% and stored with poly packaging) coating treatment on shelf life of grapes which stored under 0°C and 30°C in incubator and refrigerator and found that 20% *Aloe vera* gel coating concentration was more efficient and appropriate for enhancing the shelf life of grapes. They concluded that applying lower temperature during storage grouped with edible coating treatment and packaging enhances the marketability by decreasing rate of water loss and spoilage caused by fungal infection can be curtailed.

Gardesh et al., (2016) conducted a trial to study nano chitosan based coatings on apple *cv*. Golab Kohanz. They found that percentage of weight loss after harvesting was decreased comparatively and also the rate of respiration, ethylene production and peroxidase activity was significantly reduced.

Rao et al., (2016) investigated the effect of alginate olive oil coating to prolong the storability and postharvest value of ber fruit in which they evaluated the impact of composite coatings olive oil (0.2%) and Sodium alginate (2%) alone and with conjugation of citric acid & 1% ascorbic acid on postharvest nutritive storage-life as well as quality of fruit which stored at 25 ± 2°C and 65% relative humidity in which revealed that composite coating of olive oil and sodium alginate was more effective in maintaining the quality of fruit by using composite enriched coatings with citric acid and ascorbic acid enhance the level of antioxidants and maintained.

Rokaya et al., (2016) studied the influence of diverse coating treatments on postharvest quality and storage period of mandarin fruit. The decaying in control fruits started in first week of storage whereas in other treatments, decaying started in second week only excluding bavistin treatment. In third week, spoilage loss occurred in all treatments. Most efficient treatment which preventing the spoilage loss was bavistin 0.7% followed by bavistin 0.1% + wax 10% and wax 10% where the highest spoilage loss was observed in control.

Vivek et al., (2016) studied the effect of different coating with combination of NaOCL and ultrasound treated kiwi at cold storage conditions and concluded the loss of pH, vitamin C, TSS (total soluble solids), firmness, acidity, total phenolic content, respiration loss, all sensory quality and microbial count and observed that fruit coated with 0.80% and 1.00% chitosan decreases the overall losses, respiration rate, microorganism growth and maintain the sensory quality of sodium hypochlorite (NaOCL) with ultrasound treated fruits during 10 days of cold storage treatment at 5° C.

Ali et al., (2015) examined the effect of chitosan combined with lemongrass oil on antimicrobial activity against anthracnose of bell pepper. Lemon grass oil of concentration 0.5% and 1.0% was enriched with chitosan solution of 0.5 % and 1.0% and control of anthracnose of bell pepper in vivo and in vitro was evaluated. 0.5% lemongrass oil and 1.0% chitosan found more effective in controlling fungal growth in vitro. The in vivo results confirmed that the use of 1.0% chitosan and 0.5% lemongrass oil was significantly superior in keeping. However, chitosan individually works effectively in anthracnose disease incidence and in extension of bell pepper storage-life.

Bhowmick et al., (2015) examined effectiveness of coating material on ber's shelf life (*Zizyphus mauritiana* Lamk.) fruits kept at room temperature by using different concentration of chitosan, guar gum and gum tragacanth in which as compare to others 1.5% concentration of guar gives better results. After 3 days of treatment there is minimum loss in weight was observed minimum (8.89%) in T_5 followed and there was maximum physiological weight loss found in T_{10} (15.15%) in the fruits under ambient conditions. Minimum reduction found in T_5 probably due to coating treatments which made a hurdle against oxygen, carbon dioxide and moisture by which transpiration and respiration rate is reduced.

Cruz et al., (2015) investigated the influence of diverse coating material on sensory quality and storage life of pears using edible coating treatment in which they use different concentration of gum Arabic, candelilla wax, pomegranate polyphenols and jojoba oil were used to maintain the quality and shelf life of fruit and results showed that fruits treated with gum Arabic 4%, candelilla wax 3%, pomegranate polyphenols 0.015% and jojoba oil 0.15% increase their shelf-life of pears and accepted by consumers.

Khaliq et al., (2015) analyzed the effect of 10% gum arabic coating with 3% $Cacl_2$ on biochemical, physiological and quality of mango fruits stored at 6°C and 90% RH for 28 days and shifted to 25°C for additional 5 days shelf life. Significant results

were analyzed in fruits coated with 3% $CaCl_2$ and 10% gum arabic as compared to uncoated fruits. Combined coating of 3% calcium chloride and 10% gum arabic significantly improved chilling injury, electrolyte leakage and malondialdehyde content recorded as compare to control. Results suggested that application of 3% calcium chloride combined with 10% gum arabic might be enhance low temperature tolerance by reducing oxidative damage and improving the antioxidant defense system of mango.

Mahfoudhi and Hamdi (2015) analyzed the use of gum arabic and almond edible coating to maintain postharvest sweet cherry quality and delayed ripening at 2°C and 90-95% RH for 15 days. The use of gum arabic or almond gum (10%) increased postharvest shelf-life & quality of fruit. Fruits treated with Arabic/almond gum recorded significant decrease in fruit respiration rate resulting in decreased ethylene production. Coating also delayed firmness, soluble solids concentration, weight loss, Titrable acidity and color development as compared to untreated fruits. Result concluded that use of almond gum coating was more effective and can delay ripening which extends the storage life of fruit kept at 2°C for a time period of 15 days lacking off flavor and decay.

Meighani et al., (2015) examined the effect of various coating treatments on bioactive compounds and post-harvest quality of pomegranate fruits by using chitosan (1% and 2% w/v), resin wax and carnauba wax which kept at 4.5°C up to 120 days & at 20°C for 3 additional days and concluded that carnauba wax coated fruits maintain bioactive compounds and quality of fruits than other treatments.

Panahirad et al., (2015) measured the effect of edible coating treatment grounded on pectin and carboxymethyl cellulose to increase the shelf life of plum by using pectin with four different concentrations of carboxymethyl cellulose (0, 0.5, 1.0 and 1.5%) and stored at 19°C & relative humidity (65%) and detected that expect firmness and vitamin C, other parameters were affected by carboxymethyl cellulose pectin coatings. Best result found in 0.5% pectin + 0.5% carboxymethyl cellulose in all parameters which was suggested to apply on plum in postharvest periods to reduce the losses after harvesting.

Petriccione et al., (2015) examined the effect of chitosan coating on loquat to judge its nutraceutical traits. They found that bioactive compounds and activity of antioxidants was greater in coated fruits rather than the untreated ones. This was also revealed that the level of deterioration was higher in non-coated fruits.

Sharmin et al., (2015) examined the influence of different concentration of *Aloe vera* gel on shelf-life of papaya in which they concluded that *Aloe vera* gel coatings was another choice as compare to artificial preservative to improve the postharvest life period of vegetables and fruits. They used 0.5%, 1%, 1.5% along with control and results showed that 1.5% *Aloe Vera* gel coated fruits helps in maintaining the shelf-life of fruit papaya as compare to 0.5%, 1% and control.

Widodo and Zulferiyemmi (2015) considered the impact of chitosan and 1- methylcyclopropene on fruit quality and storage life of Cavendish banana and concluded that fruit responded differently to treatments of 1-methylcyclopropene and chitosan at early and late stage. At early stage, fruit coated with chitosan showed deterioration in quality of fruit and slow color development, but at late stage, fruit coated with chitosan accelerated ripening by which there was quick decreases of firmness, decrease of TSS and increase of acidity. The combined treatment of 1-methylcyclopropene and chitosan was best applied at yellowing stage of fruit.

Xing et al., (2015) determined the influence of chitosan treatment by means of cinnamon oil on physiological & quality of Chinese jujube in storage at 4°C for a period of 60 days and reported that the decaying and weight loss of ber fruit were considerably decreases by using chitosan along with cinnamon oil throughout 60 days of storage period and showed beneficial effect on maintaining the sensory quality. However, vitamin C, Titrable acidity reduced to 3.08 mg and 0.342% respectively in coated jujube fruits with 1.0% and 0.10%. Results suggested

that chitosan along with cinnamon oil might be helpful in preservation of jujube fruits throughout storage.

Bahnasawy and Khater (2014) examined the impact of different concentration of paraffin wax (0, 25, 50, 75 and 100%) and stored at 4 temperature (5°, 10°, 15° and room temperature at 25° C). Change in volume, weight loss, length, diameter, surface area, hardness and TSS were considered & observed that storage life of fruit increases as concentration of wax increases but it increases with temperature from 173.4 to 231.6 hours with increasing concentration of wax from 0–100% and the shelf-life of fruits increased from 98.40–288.48 hours when temperature increased from 5° C-25° C.

Chauhan et al., (2014) reported the efficiency of $Cacl_2$ and chitosan coating on postharvest storage life of mango and in combination of hurdle technology in which they used both coating separately with combination of hurdle technology for the enhance the storage life of mango during storage at 15± 1°C & 85% relative humidity. Shelf-life of fruits was recorded 60 days which treated with chitosan and calcium chloride. But with combination of hurdle technology 65 days shelf was noticed along with chitosan and calcium chloride treatment. Weight loss firmness, microbial count, TA ,skin color, TSS were evaluated by using $Cacl_2$ and chitosan and combination of chitosan and $Cacl_2$ coated fruit showed more effectiveness.

Davila-Avina et al., (2014) observed the influence of coating treatments on antioxidant and bioactive compounds of tomatoes at different stages with carnauba wax and mineral oil coating on 2 maturity stages over 28 days and stored at 10° C and accomplished that flavonoid, total phenolic and lycopene content were considerably inferior for treated fruits than untreated fruits. Despite that, the content of vitamin C was found high in carnauba wax treated breaker fruits followed by fruit striated with mineral oil and untreated. No significant difference found in pink tomatoes. Radical scavenging activity and trolox equivalent antioxidant capacity values were found higher in control as compare to coated fruits and concluded that edible coatings was another way of preservation but it changes the antioxidant activity and bioactive compounds of tomatoes which was negative effect of coatings. Both edible coatings had a significant impact on antioxidant capacity and bioactive compounds of fresh tomatoes. While lycopene and phenol values were found more in control fruits. Treated fruits showed higher antioxidant capacity values in fruits as compare to control.

Gill (2014) reported that 100 ppm vitamin C treated guava fruits disclosed the lowest average physiological loss in weight in comparison with control.

According to Hassan et al., (2014) studied that influence of wax treatment on tangerine citrus fruit and concluded that at lower temperature during the storage period (5° C), the decay % age of treated fruits was lesser in relation to non-coated fruits and 15% wax coated fruits has higher spoilage percentage at ambient conditions (25° C).

Hassanpour (2014) reported the influence of *Aloe vera* gel treatment on antioxidant enzyme activities, antioxidant capacity & deterioration in raspberry. The investigated parameters included total anthocyanin, antioxidant enzyme activities, antioxidant capacity, total phenol and post-harvest quality after eight days of storage period at 4°C, compared to the control fruit group. Coated fruit showed a higher anthocyanin, total phenols and antioxidant capacity than untreated berried group. There was less decaying found during storage period at 4°C than untreated berries which increased the post-harvest life of *Aloe vera* treated berries. However, pH, acidity, TSS was primarily affected in storage period.

Hedayati and Niakousari (2015) examined the influence of coatings with gum arabic and silver nanoparticles on microbial properties and physico-chemical properties of green sweet pepper for the duration of 21 days in storage. Arabic Gum mixed with silver nano particles significantly lowered physico-chemical losses, hindered microorganism growth and exhibited

the better performance in extending the storage life of green sweet peppers.

Ibrahim et al., (2014) examined the effect of chitosan coating having less molecular weight on shelf-life & physico-chemical properties of annanas at ambient condition (30 ± 1° C /75 ± 5% relative humidity) and observed that irradiated (15 kGy) chitosan showed superiority in extending the life period of fruit and help of maintain quality during storage period with least loss of moisture, enlarged ascorbic acid, shriveling, protection against growth of fungus and maintain superior sensory characteristics.

Kou et al., (2014) examined the influence of pullulan (1%), chitosan (2%) and calcium chloride (2%) coating treatment on antioxidant activity in pear concluded that chitosan 2% and pullulan 1% are finest coatings for pear *cv*. huang guan.

Krishna and Rao (2014) observed the delay in ripening process & extended storage life up to seven days at ambient temperature of cv. Allahabad Safeda of guava fruits when treated with 1 percent chitosan. Along with this, the post-harvest quality and desirable texture of the fruit has been retained till the close of their storing life.

Mahajan and Singh (2014) examined the effect of coating on storage life & post-harvest physiology of kinnow fruit under controlled conditions in which they use terpenoidal oligomer, cellulose, sta-fresh and citrashine at 18-20°C and 80-85% relative humidity and revealed that fruit treated with terpenoidal oligomer or citrashine can be effectively stored for 15 days in controlled conditions as compare to control in which fruit storage life maintained for 7 days only.

Misir et al., (2014) examined the effect of edible *Aloe vera* matrix treatment on fresh fruit. They concluded that colour of the fruit is one among the significant visual attributes. *Aloe vera* gel coating hindered the green colour damage of the skin of apple fruit kept at cold conditions (2° Celsius) for six months. The colour of skin of grapes exhibited lower increment in *Aloe vera* coated fruits than those kept in control. Grape fruit is rich source of anthocyanin's and accounts for the red colour of fruit. The ripening procedure of grape is connected to anthocyanin compounds. Towards the end of cold storage (1° Celsius, 95% Relative Humidity), untreated fruits showed a more red and dark colour than *Aloe vera* treated fruits. The ethylene production rate is altered by the modified conditions created by the *Aloe vera* gel coating, resulting ripening delay, anthocyanin accumulation, chlorophyll degradation, and carotenoid synthesis and eventually decay in color change in fruits.

According to Mahajan et al., (2013) concluded that the kinnow fruits coated with Nipro Fresh SS 50T or SS 40T shows noteworthy delay in TSS change, Titrable acidity and ascorbic acid content under storage.

Brishti et al., (2013) examined the influence of bio-preservatives on papaya to calculate the influence of coating on appearance and ripening behavior of papaya. The average size value of *Aloe vera* (86.730 mm) & papaya leaf extract included *Aloe vera* gel (86.12 mm) coated fruits was significantly dissimilar from fruits in control (69.99 mm) subsequently after 8 days of storage water loss, shrinkage of fruit and weight loss. The size of the fruit was determined to conclude the impact of coating material on fruit shrinkage. The drop was maximum (16.98 mm) in the papaya leaf extract included aloe gel coated fruits (0.45 mm) subsequently after 8 days of storage. It was because of the high loss of moisture in fruits kept under control & less in treated fruits.

Gol and Rao (2013) observed the influence of waxing treatment on ripening of banana fruits in which calcium chloride 1% and 1.5% ($CaCl_2$), chitosan 1% and 1.5 % alone and with GA_3 100 ppm, glycerol 98% and jujoba wax coatings & evaluated the postharvest quality and shelf-life of banana which kept at 34 ± 1° C and 70-75% RH. They concluded that chitosan 1.5% alone and with GA_3 100 ppm observed most efficient and defending coating treatment on banana fruit for maintaining the shelf life, quality and protect the important characteristics of banana during the storage.

Hassan et al., (2013) conducted a study on tangerine citrus (*Citrus reticulata*) to examine the effect of wax coatings on fruits. Various concentrations of wax viz. (10, 12 and 15%) were used as a treatment on fruits and were kept at 2 different temperature stages (5°C and 25°C) with RH (85-90%). The study concluded that 12 % wax along with storage of fruits at 5°C stated as greatest promising.

Mahajan et al., (2013) studied the effect of exterior coating on kinnow fruits. The fruits coated with ―Nipro Fresh SS 40T and SS 50‖ formulations, desiccated & kept in CFB containers, exhibited substantial impact in suspending loss of weights.

Shariatifa and Jafarpour (2013) observed the effect of coating treatments on shelf-life span and post-harvest quality of apple in which they compared coated and non- coated fruits and stated that fruits respire continuously after harvesting and coating treatment is a way to minimize the post-harvest losses of fruits. They noticed that coating treatments considerably decreased the weight loss and delayed softening of apple fruit. Taste, appearance, color, tenderness and overall acceptability of treated fruits were better while storage at 4°C for 112 days.

Shiri et al., (2013) determined the influence of chitosan layer to improves the post-harvest quality and shelf life of table grape by using 0.5% and 1% chitosan concentration at 0° C for 60 days and observed that TSS, acidity, TSS/acidity levels were superior in coated fruits but there was not any major dissimilarity found among 0.50% and 1.0% treatment of chitosan. However total amount of phenolic, antioxidant capacity & catechin were delayed in coated berries, whereas total quercetin and quercetin 3- galactoside were found high in control treatment.

Boonyakiat et al., (2012) studied the influence of different coating material on small (92-98 g) and large (135-140 g) sized tangerine fruits treated with Fomesa or Zivdar along with a control non-coated treatment stored at normal temperature (24±3°C) and RH (59±6%) for ten days. They reported that the fruits of big size have less loss in weight, better visual appearance and good flavor than the small sized fruits. Also, the size of fruit had impact on TSS, hue angle of peel color, pH & Titrable acidity but had little effect on juice ethanol content, internal CO_2, internal O_2, alcohol dehydrogenase (ADH) activity, pyruvate decarboxylase (PDC), TSS/TA ratio & ascorbic acid content. Least loss in weight was exhibited in tangerine fruit coated with Fomesa.

Diaz-Mula et al., (2012) observed the effect of alginate coatings on bioactive compounds and fruit quality of sweet cherry fruit during storage in which sodium alginate based edible coatings were used in diverse concentrations (1, 3, and 5% w/v) and reported that coating treatment were effective on postharvest related parameters such as loss of Titrable acidity, color and reduction of the rate of respiration. In addition, coatings also helps to maintaining higher concentration of antioxidant as well as phenolic activity as comparison to untreated fruits due to senescence and over ripening process.

Study conducted by *Ergun and Satici (2012)* examined the effect of coating of Aloe Vera gel of various concentrations on apple. They found that aloe Vera gel considerably retarded the loss of green colour of Granny Smith apples but it had no effect on Red delicious apples.

Hong et al. (2012) reported that 2.0 % chitosan significantly reduced firmness; weight loss increases the antioxidant ability of guava by delaying the ripening process.

Moalemiyan and Ramaswamy (2012) investigated the effect of pectin based film coating on Mediterranean cucumber for increasing the shelf- life and quality retention. They conducted that the pectin based film coating delay spoilage and increase shelf-life of cucumber which was observed by external appearance, shrinkage, loss of color, spoilage and loss in weight. The loss of colour, spoilage, weight loss and wilting was high in uncoated as compare to coated cucumbers stored at 12°C and 23°C. And most suitable storage period for uncoated fruits which was for 2 days at 23° C and the coated fruits were accepted

for 10 days. It is possible to enhance the storage life of cucumber for long time using coating at the right time and manage the variations at the time of storage of fruits at different conditions.

Study conducted by *Mohebbi et al., (2012)* exhibited the influence of gum tragacanth and *Aloe vera* gel coatings on physicochemical properties of bell pepper and kinetics of its color change at the time of storage at 4°C, 10°C, 15°C and 23°C for 30 days. 4°C and 10°C showed significantly superior then other temperatures and control in terms of shrinkage, hardness and weight loss. Higher temperature resulted in more rapid changes.

Moraes et al., (2012) analyzed the influence of carrageenan (0.5%) and alginate (2 %) coating to improve the shelf-life of Wil iams's pear & investigated that coatings influenced chemical and physical characters of fruit like pH, color, weight loss, TSS and firmness. Alginate coated fruits showed the superlative results and helped in increasing shelf-life fruit.

Ali et al., (2011) worked on effect of chitosan coating on papaya physicochemical characteristics during cold storage conditions at 12°C and 55-90% relative humidity. They reported that chitosan was helpful in maintaining firmness, soluble solids concentration, delayed changes in peel colour, weight loss during storage period of 5 weeks. The amount of titratable acidity declined during the storage period at slower pace in the chitosan treatment in comparison to uncoated fruits. Chitosan coating also retained the effectiveness in sensory properties and can be used commercially for extending storage of Eksotika II papaya fruit.

Chauhan and Bawa (2011) carried out an experiment by coating apple slices with shellac and aloe vera gel paste coating. They found that treated samples had reduction in polyphenol oxides and peroxidase activity. Rate of respiration, ethylene production and electrolyte leakage were also restricted by application of aloe vera gel.

Ghasemnezhad et al., (2011) performed an experiment by treating loquat with chitosan coating at temperature of 7°C and RH 88±2 % for 28 days. They revealed that coating had restricted the flesh browning and weight loss at lower temperature than control. Also the content of vitamin C, pH and total soluble solids had increased. At low temperature it was helpful in maintaining antioxidant capacity of fruits.

Hu et al., (2011) examined the influence of wax covering on after harvest physiology & appearance of pineapple in cold store and concluded that in wax coating and control treatment weight loss was increasing continuously with storage period. The loss in weight in control was significantly more in wax coating on 7th and14th day of storage. At the end, wax treated fruits showed 2.6% weight loss where the control showed 3.1% loss in weight.

Mahajan et al., (2011) examined the influence of edible coatings on storage life and quality of pear under cold storage (20-22° C & 80-85% Relative Humidity) & ambient conditions (30-32° and 60-65% RH) by using stay-fresh, carnauba, citrashine and oligomer terpenoidal. They concluded that citrashine followed by terpenoidal oligomer treatments found more operative in storage-life extension & retain the quality of pears in ordinary and super market conditions.

Marpudi et al., (2011) examined the influence of antimicrobial *Aloe vera* coating to enhance the storage life and quality of papaya fruit. Coated fruits with aloe vera (50%), papaya leaf extract included *Aloe vera* gel 1:1 & 2.5% chitosan & stored at 30° C & 42- 55% relative humidity and observed that the treated fruit survived for 15 days where untreated control fruits decay within 10 days. On the bases of overall experiment all physiological changes, antimicrobial *Aloe vera* gel treatment has been found as a appropriate way to enhance the storage lifespan of papaya fruits.

Navarro-Tarazaga et al., (2011) worked on coated plums postharvest quality (Angeleno) revealing that HPMC based edible film that contained bee wax expressively decreased plum weight loss, while no weight loss variances were observed in non-coated and HPMC coated fruit of plum with no bee wax. They recommended that

coatings must contain a hydrophobic compound to improve moisture barrier of Angeleno' plums.

Shahid and Abbasi (2011) studied the influence of bee wax at the amount of 1.3% and 5% on physiological changes in sweet orange and revealed that bee wax (5%) used with benlate (0.5%) showed better result which is more efficient to upsurge the shelf life of fruit sweet orange *cv*. Blood red at normal conditions during January, February and March.

Xing et al., (2011) observed the effect of chitosan treatment enriched with cinnamon oil on quality of sweet pepper and stored at 8°C for 35 days. Chitosan and along with cinnamon oil coating showed the effectiveness on decay of sweet pepper. At the end, fruit coated with chitosan coating maintained better sensory suitability, where the sensory superiority of uncoated fruits grows into non-acceptable. The high activity of scavenging antioxidant enzymes includes superoxide dismutase; peroxidase and catalase in coated peppers at 35th day should be added to chitosan combined with coating of cinnamon oil. Result suggested that chitosan along with cinnamon oil might be effective coating which maintain the quality of sweet peppers.

Ali et al., (2010) analyzed the edible coatings for augmenting shelf life and also the post-harvest appearance of tomato fruits by taking gum arabic in aqueous solutions (5, 10, 15 and 20%) application on green and matured tomatoes kept at 20°C and relative humidity (80-90%) for 20 days. Fruits treated with gum Arabic (10%) revealed delay in softening, soluble solids concentration, decay percentage, weight, Titrable acidity, Vitamin C and colour development in relation to uncoated fruit. 10% gum arabic was effective in delayed ripening process and extended storage life of tomato fruits stored at 20°C.

Maqbool et al. (2010) studied the use of chitosan on banana and established that the chitosan supressed the progression of *Colletotrichum musae in* comparison to control. The chitosan treated bananas with 1.5% concentration exhibited highest fungicidal effects followed by chitosan (1%).

Abbasi et al., (2009) examined influence of the chitosan coating treatment on postharvest worth of mango fruit, stored at 15°C ± 1°C and 85% relative humidity. They revealed that crab chitosan when irradiated @ 200 kGy has prolonged the life period of fruit mango in which there is less loss of fruit weight, fruit able to keep its sensory characteristics and increased ascorbic acid content. Irradiated chitosan coating protected the fruit from disease attack which helps to improving the shelf-life well as fruit quality.

El-Anany et al., (2009) observed the effect of coatings on storability & appearance of anna apple in cold stores in which they evaluate the effect of jojoba wax, Arabic gum, soybean gum, glycerol and paraffin oil coating at 0° C along with 90-95% relative humidity. Results showed that treated fruits found a significant effect which delays the firmness, weight loss, colour, total soluble solids and Titrable acidity change in relation to untreated ones.

Mahajan et al., (2009) studied the 5% loss of weight of guava fruit during storage was the maximum permissible limit beyond which the guava fruit show shriveling sign and turn out to be unmarketable.

Pandey et al. (2009) examined the influence of growth retardants, gamma- irradiation & coatings on storage-life of winter guava fruit by using liquid paraffin, coconut oil and mustard oil during storage. And concluded that coconut oil treated fruits were adequate to improve the storage life of fruits of guava and harmless which reduces of PWL, TSS, total sugars, vitamin C and firmness.

Saputra et al., (2009) observed the effect of chitosan treatment on organic fruits as preservatives and observed that the coating of chitosan on decreases the loss in weight of sliced mango fruits. After 7 days in storage period, there was less weight loss recorded in coated sliced mango 10.27% as compare to control which was 19.86%. The coating treatment modified the

internal atmosphere or turn as an obstruction between internal & external atmosphere which decreases the transpiration, respiration and ripening of fruits.

Wijewardane and Guleria (2009) observed that coating apple with potato starch @2% + apricot kernel oil (2%) demonstrated most efficient in holding the whole quality followed by apricot kernel oil (2%) and corn starch @ 2% +. All treatments potato starch (2%), rice starch (2%), corn starch (2%) along with neem kernel oil (0.5, 1, 2°/o) and apricot kernel oil (2%) resulted in significant reduction in PLW , fruit firmness, pectin content and Titrable acidity during period of storage.

Dang et al., (2008) observed the coating influence on fruit quality, ripening behavior and aroma biosynthesis of mango in which hard mature green mangoes were treated with semperfresh (0.6%), *Aloe vera* gel (100%) and mango/carnauba (1:1 v/v). After coating, fruits were dried at normal temperature and were kept in soft board trays for ripening at 21± 1°C & 55.2 ±11.1% RH till eating firm stage. Carnauba coating was beneficial in delaying fruit softening & ripening and enhancing fruit quality including level of aroma volatiles and fatty acids. *Aloe vera* and super fresh slightly delayed ripening of fruit but reduced volatile aroma development. *Aloe vera* treatment did not outstrip the marketable carnauba wax & semperfresh in improving aroma volatile biosynthesis and delaying ripening of mango fruit.

Geraldine et al., (2008) assessed the influence of agar-agar based (1 %) coatings added with chitosan (0.2 %), acetic acid 0.2% on minimal processed cloves of garlic. Water loss in treated cloves of garlic was, 3 times lower compared to the control. Along with significant upsurge in colour difference of control cloves as related to the further treatments. Aerobic mesophilic and filamentous fungus were noted when cloves of garlic coated with CH_3COOH + chitosan incorporated antimicrobial compounds.

Hernandez-Munoz et al., (2008) observed the influence of chitosan treatment combined with postharvest calcium treatment on strawberry fruit in refrigerated conditions (10° C and 70± 5% Relative Humidity) in which they coated the fruits with chitosan 1% or 1.5% or chitosan with calcium gluconate. Chitosan coated fruit@1.5%were observed less PLW and decreasing darkening. Whereas 1% chitosan coating increased the firmness of fruits.

Liu et al., (2008) observed the influence of chitosan on pear at normal temperature and concluded that it had positive effect on keeping decay of fruits in control and shelf life was also prolonged. Also, 1.5% chitosan proved better in controlling decay of fruits.

Reddy et al., (2008) observed the influence of different wrapping material on quality and storage life of citrus (acid lime). The protective covering material of fruit with LDPE set up to be more efficient in reducing the increase in TSS, vitamin C, pH and Titrable acidity and effective in preventing the PLW.

Shein et al., (2008) studied the effect of wax on ―Sai Nam Peung‖ mandarin fruits after harvesting. The treated fruits with food grade shellac and 18% teva wax and kept in cold store conditions for 30 days. In this study, this was seen that there was not at all substantial change in TSS/Acid ratio during storage.

Tapia et al., (2008) investigated that adding L-ascorbic acid into the coatings/films assisted to reserve the natural Vitamin C content in the freshly cut papaya It also helped in maintaining nutritional quality.

According to *Zhou et al., (2008)* investigated the effect of different coatings on pear. The coatings that were applied are carboxy methyl chitosan (2.0 g), Semperfresh TM (1.0gm), shellac (14.3g) individually in 100ml of water in cold storage (4°C). The TSS, Titrable acidity and vitamin C rate in pears reduced greatlyin all coatings after 2 months in storage period.

Chien et al., (2007) observed the effect of various treatments on mango (sliced) with solutions of chitosan (0%, 0.5%, 1% or 2%) and then stored at 6°C. Changes in flavor, hue and moisture loss were recorded. The chitosan coating decreased

moisture loss and, increased the Titrable acidity, TSS and ascorbic acid content. Along with this, the microorganism‘s growth was also inhibited.

Chlebowska-Smigiel et al., (2007) studied the effect of the pullulan protein and pullulan edible coatings on apple during storage. Pullulan edible coatings expressively restricted apple mass loss. The apples treated with coating material exhibited lower mass loss than the untreated ones. Smallest mass loss was recorded in apple fruits treated with the coatings where the pullulan to protein ratios were 6:4 and 5:5. It was exhibited that when protein was added to pullulan, the coating gets stick better to apple surface. Throughout the storage period, the protein-comprising layer was less vulnerable to decaying & to peel off.

Jitareerat et al., (2007) studied the influence of chitosan coating treatment on mango enzymatic activity, disease development and ripening by using 0.5%, 1.0%, 1.5%, and 2.0%/ chitosan in 0.5% acetic acid and concluded that coating contain chitosan effected less, however high concentration like 1.5% and 2.0% were effected than the 0.5%, 1.0% and control. Chitosan coatings showed delayed ripening, ethylene synthesis and reduce the degree of respiration & loss of weight, Titrable acidity and ascorbic acid in mangoes. But in sensory quality, the firmness of mangoes coated with above 1% affected more in terms of noticeable decline.

Durango et al., (2006) reported that the presence of chitosan at the concentration of 1.5 % in the coatings inhibits the development of lactic acid bacteria during the storage.

Hernandez-Munoz et al., (2006) evaluated the effectiveness of chitosan (CS) 1 and 1.5 percent of chitosan mixed in calcium gluconate to prolong the storage of Strawberry. Firmness in strawberry had been increased by addition of calcium to the chitosan solution.

Martínez-Romero et al., (2006) observed the effect of *Aloe vera* as coating on postharvest safety & quality maintenance in sweet cherry and concluded that during cold storage period, untreated fruit exhibited increase in PLW, enhanced softening, respiration rate, color change, microbial population and stem browning. Whereas *Aloe vera gel* treated sweet cherry fruits showed marked delay in postharvest quality loss parameters and sensory evaluation parameters. *Aloe vera* gel would be novel and fascinating coating for commercial use and a substitute of postharvest chemical coatings.

Matuska et al., (2006) found that double or single sodium alginate coatings suppressed leakage upon freezing/thawing of osmotically treated fruits of strawberry.

According to *Serrano et al. (2006)* stated that table grapes coated with Aloe vera stored for 35 days at 1°C and monitored at 20°C indicated that clusters which were uncoated exhibited a quick decline of functional compounds like total phenols & acerbic acid.

DelValle et al., (2005) studied the effect of prickly pear, cactus mucilage, as an edible coating to improve the storability of strawberry fruit and were tested to regulate their influence on colour, sensory quality & texture of fruit. Use of coatings increased strawberry shelf life.

Jayachandran et al., (2005) observed that the shelf life of superior physico- nutritional status of guava fruit was improved by antioxidant application after harvesting.

Kamble and Chavan (2005) reported that Corn starch (6°/o) treated custard apple fruits which were fully mature & freshly harvested found to be extended storage period up to 8 days.

Ladaniya et al., (2005) studied the effect of cold storage of ―Nagpur mandarin‖ in combination with coating of wax& alternating warming. The outcomes exposed, alternating heating and coating with wax were beneficial in increasing the storage ability of ―Nagpur mandarin‖ for seventy five days.

Maftoonazad and Ramaswamy (2005) observed the effect of coating based on methyl cellulose on the colour, respiration rate and fruit texture of avocados kept at ambient temperature. The

appearance of brown spots normally related to ripening was hindered in fruits coated.

Tanada-Palmu and Grosso (2005) observed the impact of wheat-gluten based layers on strawberry fruit quality under refrigerated condition. The film of wheat-gluten, stearic & palmitic acids and bee wax had a positive impact on the firmness, weight loss.

According to *Ayranci and Tunc (2004)* evaluated the performance of the edible coating on vitamin C and water loss of green peppers. Major component of the coatings were polyethylene glycol and methyl cellulose. Ascorbic acid and stearic acid were added in coating formulation and found that coatings reduced the water loss in green peppers and apricots. Coating formulation methyl cellulose - polyethylene glycol – stearic acid was found most valuable in water loss in jujube fruits. Ascorbic acid in coating formulation as antioxidant lowered the loss of vitamin C. Edible coating of different compositions on fresh fruits of apricot and green pepper reduced the rate of water loss from green peppers and apricot.

Han et al., (2004) studied the performance of the chitosan coating on strawberry and red raspberry. Strawberries (*Fragaria* × *ananassa* Duch.) & red raspberries (*Rubus ideaus*) were stored for 3 weeks at 2°C(Temp.) and 88% (RH) or at -23°C up to 6 months respectively after coating with 2% chitosan. The results showed that fresh strawberries & red raspberries stored at 2°C& 88% RH showed less spoilage in comparison to control.

Plotto et al., (2004) observed the effect of submerging mango fruit for thirty sec. in N -acetyl- L-cysteine (0.5%), calcium ascorbate (2%) and chlorine dioxide (5ppm) (antioxidants), or in maltodextrin (CMM) (0.5%) or carboxymethylcellulose or CMC (1%) coatings. The treated fruits and those treated with antioxidants and kept at 5°C sustained better outer appearance next 3 weeks when related with control. When kept at 10°Celsius, the outer appearance of the 2 control treatments were the least, but overall, no treatment was satisfactory 14 days afterwards. CMC-treated fruits tend to be more firm when kept at 5°Celsius in storage after 11 days, but not at 10°Celsius.

Zhang et al., (2004) observed the physical and physiological changes in cucumber after coating with edible films & ozone water. The experiment revealed that the use of coatings can also subordinate the TSS (total soluble solids) content and prevent the PPO (polyphenol oxidases) activity.

Lee et al., (2003) determined the influence of several coatings with anti-browning agents on apple slices. In carrageenan (0.5 g/100 mL)-coated fruits, there was decrease of 5% in respiration rate while fruits coated with whey protein concentrate (5 g/100 mL) showed 20% decrease of respiration rate at 25 °C. Use of edible coatings mixed with anti- browning agents enhanced the storage ability of apple slices for fourteen days when kept at 3°C.

According to *Salvador et al. (2003)* edible coatings retard moisture loss, slows physiological loss in weight, prevent microbial spoilage, softening and retain the fruits colour during storage.

Hoa et al., (2002) observed the effect of different coating treatments on the shelf life of mango and used four coatings containing shellax, carnauba wax, zein and cellulose. Carnauba wax was superior then all other coating materials which reduced the weight loss for a long time. After 17 days of storage, fruits treated with carnauba wax showed less weight loss 15 %, which was minimum when compared to control treatment and other coatings. Coating was most successful for retarding weight loss. The reason for the weight loss reduction may be due to the blockage of stomata that results in reduction of respiration and gas exchange.

Yaman and Bayoundurlc (2002) revealed that to increase the lightness in sweet cherry, the sucrose polyester (Semperfresh TM) coating found to be effective.

Jiang and Li (2001) studied that chitosan coating could prolong the post-harvest life of longan fruit and maintain their quality.

Chen and Nussinovitch (2000) compared performance of locust bean gum and non-gelling xanthan gum as wax formulations on Nova and Michal cultivars of citrus. Both treatments contributed in reducing loss in weight of the fruit.

Rasool (2000) reported that in ―Red Delicious‖ apple, the maximum average (9.60%) of total sugars were found after storage for 105 days under ambient condition in case of control and minimum of 9.06% were found in Stay fresh treated fruits. Similarly, the maximum average (7.11%) of reducing sugars in case of control and minimum of 6.67% in fruits treated with Stay fresh.

Arvanitoyannis (1999) reported that chitosan is being biodegradable and edible coating material, has a great potentiality for use in food packing, thus, making it a potential raw material for edible coatings and films.

Dashora et al., (1999) stated that in ber variety (Umran) 2°/o edible oil coating prolong the storage period up to 12 days at room conditions & decreased the losses during postharvest without any unfavorable impact on acidity, TSS, ascorbic acid and amount of sugars during storage.

Tasdelen et al., (1998) recorded that edible semperfresh coated tomatoes were significantly effective at storage temperature to delay changes in firmness, PH, TSS, acidity, sugar, weight loss ,ascorbic acid & reduced microbial spoilage during storage.

According to *Singh et al., (1997)* fruits of guava fruit cultivar Allahabad Safeda were found to retain good organoleptic properties up to 12 days of storage at ambient condition when coated with 6-12 % Waxol or 3-6 % corn starch.

Das and Medhi (1996) suggested that 6% corn starch treatment noticeably decrease weight loss, change of color, increases (TSS) Total Soluble Solids and Total amount of sugars after twenty-one days of storage period.

Lord Thanangkul and Krochta (1996) studied the post-harvest effect of edible coating on green bell peppers. They concluded that no coating applied showed significant effect on color changes at the time of storage. Results showed that color of treated green pepper bell did not change in relation to control treatment.

Sindhu and Singhrot (1996) recorded extreme deterioration harm in mustard oil as compared to Til oil coated fruits. TSS, Titrable acidity and vitamin C of lemons were increased with increasing storage periods.

Study conducted by *Sarkar et al., (1995)* revealed that banana fruit can be stored for fourteen days after harvesting without significant influence on the post-harvest quality when they were treated with 6 percent waxol.

Jagdeesh (1994) reported that sardar guava fruits after post-harvest treatments of 6 percent corn starch prolonged the storage period of fruits to 9 days. The fruits which were treated showed decreased PLW and reserved higher content of TSS, vitamin C, acidity, total amount of sugars, reducing sugars and organoleptic scores during storage period.

Singh et al., (1993) exhibited that wax coating were superior in extending storage ability of guava (*cv.* Allahabad Safeda). They found less PLW, refining color development gloss and retaining chemical constituents during fruit storage.

Aworh et al., (1991) established that waxing minimized loss of weight in oranges & grape fruits. Over 31 days of storage, weight loss in control was 20 percent compared with 13.8 percent in waxed fruit.

El-Ghaouth et al., (1991) observed that storability of various perishable fruits such as strawberry had been improved by chitosan coating.

Guatam and Chundawat (1990) observed that the accumulation of TSS during the process of ripening in sapota. But, when the fruits treated with different chemicals the accumulation of TSS decrease or lower in comparison to untreated control. In sapota cv. Kalipatti, there was a slow decline in Titrable acidity throughout the period of ripening. However, the decline of Titrable

acidity diverse among treatments being most quick in GA (30 ppm) and the lowest in the control. The upsurge in TSS content in sapota delay when stored at zero energy cool chamber and ripening of fruit also delay (Reddy and Nagaraju 1993).

Desai et al., (1989) confirmed that the Tal-prolong treated fruits had significantly higher values of starch, indicating the ripening process in these banana fruits was retarded significantly followed by those banana treated with Topsin plus wax emulsion, benomyl plus wax emulsion and wax emulsion alone. Wax emulsion was as effective as the Tal-prolong and gave the best outcome when used in combination with benomyl or Topsin.

Shivaramareddy and Thimmaraju (1989) observed a reduction in spoilage and weight loss when mango fruits (*cv.* Alphonso) were coated with wax emulsion (2, 4 and 6%) and stored in perforated polyethylene bags. They found 6 percent wax emulsion as best coating concentration over the 2 and 4% concentration of wax emulsion.

Dashora and Mohammad (1988) observed that 100 PPM 2,4-D along with 4 and 8 percent whey protein concentrate turnout to be the most suitable postharvest treatment for loss of weight, reduction of rotting, and also for maintaining superiority of fruits and increasing the shelf life & hindered ripening of fruit till 40 days.

Farooqhi et al., (1988) conducted a study on effect of wax emulsions SB65, Britex-561 and Fruitex on oranges, grape fruits, lemons and Kinnow. It was found that the wax coating enhanced the outer advent of fruits and decreased loss of weight, reserved fruit firmness, & fresh looks. Coating has also gained importance in reducing the moisture loss and maintaining the firmness during storage.

Singhrot et al., (1987) recorded enhanced shelf life (up to 35 days) of Baramasi lemon with the treatment of waxol and captan.

Ahmad et al., (1986) observed the influence of lining material & waxing on storage ability of kinnow fruits & detected that the treatment were having better impact on quality traits. The outcomes showed that the amount of Vitamin C & citric acid tends to decrease, in vice versa, sugar content and sugar/acid ratio upsurged during storage period.

Rao and Chundawat (1986) recorded significantly lesser % age of ripened banana *cv.* Lacatan fruits coated with waxol (12%) as compared with control on the 12th day of storage.

Wild and Scott (1983) could maintain lime fruits, green and marketable for 4 months by treating with wax containing GA plus 2, 4-D and storing in controlled atmosphere (1% C02, 12% O2), with ethylene removed, at10°C.

Passam (1982) noted extended shelf-life of mango fruit when coated with wax 3 percent emulsion of stay-fresh wax at room temperature (28°-32°C) during the experiment.

Singh and Chauhan (1982) reported that waxol (1-12%) coating with pre- cooling treatment improved shelf-life of guava by two days. It also reduced fruit rotting and retained higher sugars. They also found that the activity of cellulose and pectinase were lowest among wax treated guava fruits. Thus the fruit with wax coating can securely be kept for 4 days at room temperature. Wax emulsion applied to guava fruits reduced weight loss and produced a surface shine. Yellow skin color developed normally and respiration rate and ethylene production were not affected.

Wild (1981) observed that the wax coating reduced the weight loss from 11.5 to *4.3 percent in oranges stored for 21 days.*

Bhullar and Farmahan (1980) indicated that wax coating of guava fruits @6 percent postponed the ripening rate and prolonged the storage life up to 10 days; with minimum PLW (8.2%) and fruit rot (5.0%). *Jawanda et al. (1980),* similarly, also recorded less storage loss (9.32- 9.52) in ber fruit *cv.* umran and sameur, respectively, when treated with wax emulsion dipped for 30 seconds and stockpiled in polythene bags.

Roy et al., (1980) reported that the wax emulsion treatment that the Himsagar and Langra mango were found most effective in extending storage life to 10 days when compared control which was 6 days. They also conveyed that the loss in weight was maximum in control (14-15 %) and it was lowest (4.2-7.3%) in combined treatment of wax emulsion with Maleic hydrazide. In a trail to prolong the storage life of kinnow, it was found that wax emulsion (12%) was the best coating material as a treatment to minimize the weight loss of fruit. Wax emulsion (6-12 %) with and without 2, 4-D (50- 100 ppm) and cycocel (500-1000 ppm) gave better retention of juice during storage. Wax emulsions alone or in combination with 2, 4-D retarded the rate of normal change of TSS.

Pillai et al., (1978) showed that W-12 wax emulsion prolonged the storage life by 5-6 days in banana cv. Dwarf Cavendish and Nendran.

Sheikh et al., (1977) found extended shelf-life of mango fruits using fungicidal wax emulsion coating.

Garg et al., (1976) reported significantly least weight loss 25.7 and 18.4 percent in guava (*cv.* Allahabad Safeda) treated with wax emulsion, after 9 days at normal and 21 days at lower storage temperature condition respectively. Preservation of acidity and ascorbic acid was better in waxed fruits with relation to control.

Garg and Ram (1973) observed that submerging mango *cv.* Lucknow Safeda for time period of 30 to 60 sec. in 6 % wax emulsion with added sodium orthophenylphenate 0.4% for 30-60 seconds prolonged the storage life of fruit by 3 days in comparison to the control treatment at 30 degree Celsius.

Dalal et al., (1971) suggested that the usage of wax emulsions (4-6%) extends the shelf-life of the several fruits minus any negative impact on the quality.

Garg et al., (1971) stated that the reducing sugars in untreated fruits were maximum as compared to treated fruit. In Patharnakh variety of pear, when storage period extended, the amount of total sugars also increased.

Muthuswamy et al., (1971) reported reduced PLW (%) of banana fruits treated with of 6 and 12 percent wax emulsion. Further, they concluded that the application of paraffin wax to cut end surface slightly reduced PLW (%).

Fruits are living tissues, as they continue to transpire and respire even after harvest. PLW is mainly because of the respiration and transpiration *(Krishnamurthy and Subramanyam 1970). Davies et al., (1981)* found that desiccation and shriveled appearance of fleshy fruits are because of PLW which indicate moisture lost during ripening and storage.

Srivastava (1962) studied the storage life of guava fruits by treating with a carnauba-paraffin or carnauba-resin wax by 80 percent at room temperature and by 50 percent at 8-10°C. Similarly, extended storage life of banana about a week has been recorded by *Agnihotri and Ram (1971).*Waxing of banana fruits was found to reduce the PLW while in non-waxed fruits increased PLW up to a period of seven days of storage under ambient condition.

III. CONCLUSION

The addition of active ingredients into the edible coating not only enhances the safety but also improves the nutritional and sensory attributes of the food consumed. The high perishability of the fresh produce can be attributed to its water content which accounts for around 80–90% by weight. The atmosphere maintenance by the edible coating ensures the least water evaporation. The efficacy of the coating material can be improved either through the development of composite polymers or through the incorporation of herbal components/essential oils and/or nanoparticles as a filler. The paradigm shift in the research developments in edible coating showcases its efficacy as becoming the choice of the future both in terms of quality maintenance and easy handling.

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Application and Property of Many Special Types Recurrence Relation Polynomials in Number Theory and their Special Representation

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ABSTRACT

It develops a formula that explicitly expresses the general term of a linear recurrent sequence, allowing us to generalize J. McLaughlin's original finding on powers of 2 matrices to the case of a square matrix of size ≤ 2 matrix. The identities of Fibonacci and Stirling numbers, as well as a variety of combinatorial relations, are deduced. It uses two-variable Hermit polynomials and their operational laws to derive integral representations of Chebyshev polynomials. Most of the Chebyshev polynomial properties can be obtained using the Hermit polynomials $H_n(x, y)$ definitions and formalism. They also show how to use these results to introduce valid generalizations of these polynomial groups and derive new identities and integral representations for them. For Chebyshev polynomials of the first and second kinds, its present new generating functions. A recurrence relation is an important mathematical concept. Recurrence relations are used in a variety of fields, including mathematics, economics, physics, and other sciences. It presents a significant finding on the convergence of recurrence relation sequences as a function of the recurrence relation coefficient.

Keywords: chebyshev polynomial, first kind, second kind, properties and applications.

Classification: FOR Code: 230102

Language: English

London
Journals Press

LJP Copyright ID: 925654
Print ISSN: 2631-8490
Online ISSN: 2631-8504

London Journal of Research in Science: Natural and Formal

Volume 22 | Issue 15 | Compilation 1.0

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ABSTRACT

It develops a formula that explicitly expresses the general term of a linear recurrent sequence, allowing us to generalize J. McLaughlin's original finding on powers of 2 matrices to the case of a square matrix of size ≤ 2 matrix. The identities of Fibonacci and Stirling numbers, as well as a variety of combinatorial relations, are deduced. It uses two-variable Hermit polynomials and their operational laws to derive integral representations of Chebyshev polynomials. Most of the Chebyshev polynomial properties can be obtained using the Hermit polynomials $H_n(x, y)$ definitions and formalism. They also show how to use these results to introduce valid generalizations of these polynomial groups and derive new identities and integral representations for them. For Chebyshev polynomials of the first and second kinds, its present new generating functions. A recurrence relation is an important mathematical concept. Recurrence relations are used in a variety of fields, including mathematics, economics, physics, and other sciences. It presents a significant finding on the convergence of recurrence relation sequences as a function of the recurrence relation coefficient.

The major goal of this study is to use Girard and Waring's numerical and numerical adoption to the problem of Chebyshev polynomials' potential values and to identify certain structures that may be lost. As a specific application of our concept, we discovered two concurrent outcomes involving Fibonacci and Lucas numbers. The major goal of this work is to employ a few Chebyshev polynomial features to focus on the challenges of mixing the Sinx And Cosx energies, as well as to identify other interesting applications.

Keywords: chebyshev polynomial, first kind, second kind, properties and applications.

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I. INTRODUCTION

It is in the area of mathematical analysis that the orthogonal Polynomial and Dynamic functions have been established continuously and orthogonal analysis is not an exception. Orthogonal polynomials are the object of extensive employment, in particular and classical orthogonal polynomials have. Several problems apply to proven math, theory physics, chemistry, approximate principles, etc, with the accidentally of numbers of problems and other disciplines as well.

A significant subject in mathematics is a recurrent relationship. It is necessary for a recurrence relationship to the subject of mathematics. In both mathematics and economy, recurrent relations are used Physics and others in subject areas. Number theories are the principal field of study which this paper explores. "Learning to the popular theorist Carl Friedrich Gauss: "Mathematics is the queen of all science, and Numbers theory is the queen of Mathematical Studies. The study of numerology is the examination of the characteristics of integer and rational numbers, which exceed the habitual tricks of math." This in which nutritional philosophy will go into his history and not like "because of set" and

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Save in. Relationships between repeated subjects are implemented in both mathematics and economics. The key effects of the convergence of the series of recurrence depend on the recovery coefficient. We're talking about a few examples. We will use recurrence in network marketing in this document. Recurrence relationships are very useful subjects for mathematics that solve many real-life problems by repeat relations. In modern times, network marketing is a very well-known business practice for a lot of people. The use of a recurrence relationship method which results based on the recurrence coefficient of the network marketing enterprise. This approach is therefore very useful in evaluating the benefit of any network marketing provider. There are some major concepts developed for recurrence relations. These personalities are very valuable in seeking the terms in any series for the recurrent correlation. In this recurring method, to find out any terms all previous terms need to be found and that result is very necessary. A partnership between an individual has a significant property terms and root polynomial values of a recurrence relations for Second Order relationship, we gave the same recurrence relationship property of all Higher Order recurrence relations. We may eventually conclude that all recurrence relationship involve roots are different, this concept, being true, all order. We may therefore presume that the text of a joint relationship between a number of variables, the values, and roots of a polynomial relationship.

First Order Recurrence Relation

In the first order recurrence relation only one initial term is given. For example

$$a_{n+1} = a_n + 5, n \geq 1, a_0 = 0$$

we can find the terms

$$a_1 = 5, a_2 = 10, a_3 = 15$$

Second Order Recurrence Relation

In the second order recurrence relation new term depend on two previous terms and two initial terms are given.

For example

Third Order Recurrence Relation

In the third order recurrence relation new term depends on three previous terms with three initial terms are given.

For example

$$a_n = a_{n-1} + 2a_{n-2} + 3a_{n-3}, n \geq 3$$

With the initial terms $a_0 = 0, a_1 = 1, a_2 = 2$

$$a_n = a_{n-1} + 2a_{n-2}, n \geq 2$$

With the initial terms $a_0 = 0, a_1 = 1$

Third Order Recurrence Relation

In the 3rd order recurrence relation new term is depend on previous three terms. For example

$$a_n = a_{n-3} + 2a_{n-2} + a_{n-1}, n \geq 3$$

With the initials terms $a_0 = 0, a_1 = 1, a_2 = 2.$

The relation between primary numbers and perfect numbers, including composite numbers, exists.

The first term will be 2 × 2 = 4, next 2 × 3 = 6, 3 × 3 = 9, etc. in composite numbers by means of primaries; 2, 3,5,7,11,13,17,19,23,29,31 etc. and by means of a composite count number, in line with the formula for m and n composites, where m and n shall be both primarily numbers. The processing is such that there is no number between them, such as 3x3, and multiply 2 by 5, to get 10. However, it is laborious to achieve composite numbers that are far-reaching, so that the nth composite number (Cn) can be produced with the Wolfram Language Code as above. It is a code for the computer. A manual algorithm for extrapolating large composite numbers is exceedingly difficult to develop. But the generating function of Dirichlet is used for the characteristic function of the composite numbers. The relationship can also be dealt with as follows in ideal numbers; (Power of Two) × (Double that Power - 1). The prime number formula is given by (2n-1). To get the Perfect Number, the formula becomes (2n-1) × (2n-1). Getting the nth sequence of a perfect number is dependent on the equivalent nth sequence of prime numbers. The research finally concludes with the call for researchers to team up to make more explicit, the recurrence relation in composite numbers. The study focuses its intention on recurrence relation in perfect and composite numbers. It is hinged at analyzing the mathematical relationships between them, as well as asking new questions about them and to prove that these relationships are true.

Recurrence Relation of Network Marketing is the sector came into being, marketing has become one of the main data mining applications. The determination whether a specific individual is to advertise is usually based solely on its characteristics or those of the population segments to which they belong (direct marketing) (mass marketing). This also results in optimum targeting choices since the impact of a business consumers on each other's buying decisions is not taken into consideration. Customers are heavily affected by the views of their partners in many markets. Viral marketing does this to sell a commodity cheaply, mostly through marketing people with the highest consumer power.

II. RESEARCH METHODOLOGY

3.1 Introduction

Methodology is a "focused paradigm' for science, a consistent and rational approach centered on opinions, and principles that direct researchers and other users to choose. It contains theorical analyses of the community of methods and concepts linked to a branch of expertise, which differs according to their historical creation in the different disciplines. These methods, described in the methodology, define the means or modes of data collection or, sometimes, how a specific result is to be calculated. Methodology does not define specific methods, even though much attention is given to the nature and kinds of processes to be followed in a particular procedure or to attain an objective.

A methodology is a system of methods and principles for doing something, for example for teaching or for carrying out research. choosing a wholly suitable and sound method that is right for research project will give the path to help succeed. A methodology will give guidelines to make the project manageable, smooth, and effective.

Research methodology defines the pattern of performing research. The research opinion preferred for this chapter is based on the type of methodology selected. With the requirements and prerequisites that are defined by an individual, a specific methodology can be selected for testing the research questions and find results accordingly. A specific time limit is defined on every segment of the study and the desired target is achieved.

1. The proposed methodology of work will be phase wise as described in the following sequence: I. Development of techniques / recent advances for application in different fields.
2. Collection of literature regarding with the apropos research work.
3. Derivation of new results related with study of generalization of Fibonacci sequence.

There are two main directions in which the Fibonacci polynomials can be generalized either the recurrence relation can be generalized and extended, or the recurrence relation is preserved but the first two terms are replaced by arbitrary terms.

Research methodology refers to the steps, procedures and strategies used for gathering data during the research investigation . This chapter is concerned with methodology used in achieving the research aim. It also contains focus the of study and instrument of data collection used.

Recurrence relation is especially useful topic of mathematics. It is an equation that defines a sequence based on a method that gives the next term as relation of the previous terms. Recurrence relation is especially useful in mathematics as well as economics. This can calculate growth in economics by recurrence techniques. In recurrence relation for finding any term of sequence itneeds to find all previous terms of sequence but by using this theorem it can find direct any term of sequence. Recurrence relation is especially useful in real life problems. Should be most of the people in the network marketing are honest, trying to earn a living to provide a high-quality lifestyle for themselves and their families.

Number Theory is the study of positive numbers (1,2,3,4,5,6,7...) which scrutinize the properties of integers, the natural numbers which is common as -1,-2,0,1,2 and so forth. It is part theoretical and part experimental, as mathematics seeks to discover fascinating and even unexpected mathematical interactions. It is the study of subtle and far-reaching relationships of numbers. This far end reaching relationships have its application in computer algorithm as in Fibonacci numbers.

Since ancient times, people have separated the natural numbers into a variety of different types which includes but not restricted to odd numbers, cube numbers, prime numbers, composite numbers, 1(modulo 4) number, 3(modulo 4) numbers, triangular numbers, perfect numbers, Fibonacci numbers, etc.

3.2 Focus of the Study

1. The study focuses on the number and polynomial number recurrence relation. It is concerned with analyzing and asking new questions about the mathematical relationships between them and showing that these connections are valid.
2. Recurrences are an extremely useful tools (sometimes unique) to solve many counter problems, where the use of established combinatorial techniques makes it challenging (or impossible) to count items. Therefore, the RR and its solution complement the experience of combinatory and therefore in the philosophy of probability and statistics. In the well-known books of Combinatory, the subject of recurrences and their resolving takes place by chance.
3. The recurrence is causally linked to the recursion, which the names indicate. The RR is used less or more in recurrence for learners and is considered in several textbooks together. The recursive computing of n! the nth number of Fibonacci, etc. are classic examples of recurring functions in any programming textbook. These features are more naturally based on the respective recurrences (i.e., recursive definitions). They can then be used to explain recursion and the main steps it takes forward steps and backward steps in the simple case (below) of the recursion (optional in some recursions). For e.g., recursive calls are defined by the subsequent recurrence and the steps forward correspond to the extension of the recurrence terms as per the iteration process (but it happens automatically, by pushing stack frames in the program stack).

As a simple case of recursion, the original conditions are used. The number and polynomial measures are inductive for the computer – beginning from the initial words, when all terms are calculated up to the (n – 1) set, the nth term is calculated (the subject “recursion and iteration” is essential and

comprehensive, so further consideration is needed). The Fibonacci number illustration is an inefficient recursion classical example. The best way to show and clarify that this recursion is inefficient is using the appropriate recursion tree. By it can infer for the utility of related function: "Let the recurrence of form (1) of order k > 1 be defined and its initial conditions. For each recurrence word, a recursive function that determines the nth term of this series with recursive calls is unsuccessful. Here are two established strategies to prevent the unsuccessful recursion: memorization (where a certain value is calculated, stored in an array that will be used any time a recurrence attempts to compute it) and repetition through iteration and usage of a stack if required (i.e., applying the bottom-up approach).The recurrences are used in the analysis of complexity of algorithms, mostly recursive. As it mentioned above, the recurrences and the recursion trees are appropriate, powerful, and unique tools for investigation the time-complexity of algorithms, based on a strategy "divide-and-conquer".

III. RESULT ANALYSIS

Analysis- Generalized Fibonacci sequences: Now, let us consider for q ≥ 1, the "multibonacci" sequence (ϕ_n^q)n≥− q defined:

by

$$\begin{cases} \phi_{-q}^{(q)}=\ldots\ldots=\phi_{-2}^{(q)}=\phi_{-1}^{(q)}=0, \\ \phi_0^{(q)}=1, \\ \phi_n^{(q)}=\phi_{n-1}^{(q)}+\phi_{n-2}^{(q)}+\ldots.+\phi_{n-q-1}^{(q)} \; for\; n \geq 1. \end{cases}$$

In[1]Belbachir and Bencherif showed that

$$\phi_n^{(q-1)}=\sum_{k_1+2k_2+\ldots\ldots+qk_q=n}\binom{k_1+k_2+\ldots..+k_q}{k_1,k_2,\ldots,k_q},$$

And, for q ≥ 1,

$$\phi_n^{(q-1)}=\sum_{k=0}^{\lfloor n/(q+1)\rfloor}(-1)^k\frac{n-k(q-1)}{n-kq}\binom{n-kq}{k}2^{n-1-k(q+1)},$$

Belongs to

$$\sum_{k_1+2k_2+\ldots\ldots+qk_q}\binom{k_1+k_2+\ldots..+k_q}{k_1,k_2,\ldots,k_q}=\sum_{k=0}^{\lfloor n/(q+1)\rfloor}(-1)^k\frac{n-k(q-1)}{n-kq}\binom{n-kq}{k}2^{n-1-k(q+1)}$$

Theorem 4.1.the identity is as following

$$\phi_n^{(q)}=\sum_{l=0}^{qm-r}\binom{n-l}{l}_q(4.1)$$

Where m is given for division via the extended euclidean algorithm: n = m(q +1)-r,0≤r≤q.

Proof. It says that

$$\phi_n^{(q)}=\sum_{k_1+2k_2+\ldots\ldots+qk_q=n}\binom{k_1+k_2+\ldots\ldots+k_{q+1}}{k_1,k_2,\ldots\ldots,k_{q+1}}$$

$$=\sum_{L\geq 0}\sum_{k_1+2k_2+\ldots\ldots+(q+1)k_{q+1}=n}\binom{L}{k_1,k_2,\ldots\ldots,k_{q+1}}$$

$$=\sum_{L\geq 0}\sum_{k_1+2k_2+\ldots\ldots+(q+1)k_{q+1}=n-L}\binom{L}{L-k_2-\ldots\ldots-k_{q+1},k_2,\ldots\ldots,k_{q+1}}$$

$$=\sum_{L\geq 0}\binom{L}{n-L}_q$$

$$=\sum_{L\geq\frac{n}{q+1}}^{n}\binom{L}{n-L}_q,$$

the fact that is using as $\binom{L}{a}_q = 0$ for a < 0 or a > qL

Consider the unique text of n given by the extended euclidean division algorithm

:n=m(q+1)-r,0≤r<q+1 then $\frac{n}{q+1}$=m-$\frac{r}{q+1}$, which gives

In[1]Belbachir and Bencherif showed that

$$\phi_n^{(q)}=\sum_{l=0}^{qm-r}\binom{m+k}{qm-r-k}_q=\sum_{l=0}^{qm-r}\binom{m+k}{(q+1)k+r}_q=\sum_{l=0}^{qm-r}\binom{n-l}{l}_q.$$

This is obtain the following identities as an immediate consequence of Theorem 4.1.

$$\phi_{(q+1)m}^{(q)}=\sum_{l=0}^{qm}\binom{(q+1)m-l}{l}_q=\sum_{k=0}^{qm}\binom{m+k}{(q+1)k}_q,$$

$$\phi_{(q+1)m-1}^{(q)}=\sum_{l=0}^{qm-1}\binom{(q+1)m-l-1}{l}_q=\sum_{l=0}^{qm}\binom{m+k}{(q+1)k+1}_q,$$

$$\phi_{(q+1)m-r}^{(q)}=\sum_{l=0}^{qm-1}\binom{(q+1)m-l-r}{l}_q=\sum_{l=0}^{qm}\binom{m+k}{(q+1)k+1}_q,$$

The classic sequence Fibonacci is found for q = 1:

$$F_{-1} = 0,\ F_0 = 1,\ F_{n+1} = F_n + F_{n-1},\ \text{for } n \geq 0.$$

Thus, it achieve the common identity $F_n=\sum_{l=0}^{\lfloor n/2\rfloor}\binom{n-l}{l}$.

Recently, Generalized Pascal triangle and sequences T_n.The following combinatorial interpretation occurs of the elements $\binom{n}{k}_s$ of the generalized Pascal triangle. The word $\binom{n}{k}_s$ assigns

the number of ways of distributing uniform objects k to n boxes, which may have a maximum number of objects in each box. Clearly, 0≤k≤sn.In other words, $\binom{n}{k}_s=|\{f:\{0\ldots,n\text{-}1\}\to\{0\ldots,s\}|\sum_{i=0}^{n-1} f(i)=k\}|$.

For example, if s = 2 the triangle is achieved

$$1$$

$$1 \quad 1 \quad 1$$

$$1 \quad 2 \quad 3 \quad 2 \quad 1$$

$$1 \quad 3 \quad 6 \quad 7 \quad 6 \quad 3 \quad 1$$

Where $\binom{n}{k}_2=\left(\binom{n-1}{k-2}_2+\binom{n-1}{k-1}_2+\binom{n-1}{k}_2\right)$, if the value is zero if v<0 or 2u<v, assumes that the u in $\binom{u}{v}_2$ is not negative. It will skip subscript 1 and write only for the normal binomial coefficients $\binom{n}{k}$ if s = 1. Now in further it is formulating a lemma for generalized binomial coefficients that is helpful in the theorem proof 4.2

Lemma 4.2. If s ≥ 2 then it will as

$$\binom{n}{k}_s=\sum_{k_1=\lceil\frac{k}{s}\rceil}^{min\{k,n\}}\binom{n}{k_1}\binom{k_1}{k-k_1}_{s-1} \tag{4.2}$$

Proof of Lemma 4.2. If it chooses to distribute k elements, then it selects k1 boxes, with at most s − 1 element per box, and then distribute the other k−k1 elements among the k1 boxes specified. $\binom{u}{v}_s=0$.

Notice that the limit indication in sum (4.2) can be ignored by reminding the coefficient $\binom{u}{v}_s=0$ for an unremarkable if the integer v is outside the range 0, ...,su.

The generalized Pascal triangle n k s , n ∈ N; 0 ≤ k ≤ sn is linked to the linear recurrence {Tn} given by (1) and (2) via the diagonal sum,

$$\sum_{k_1=0}^{\left\lfloor\frac{sn}{s+1}\right\rfloor}\binom{n-1}{k}_s=T_{n+s} \tag{4.3}$$

The case s=1 returns the nice identify,

$$\sum_{k_1=0}^{\left\lfloor\frac{n}{2}\right\rfloor}\binom{n-k}{k}_s=F_{n+1}$$

A000045 number for Fibonacci, while s=2 is related to A000073 number for Tribonacci numbers. Generalized numbers associated with Fibonacci. More broadly, the unimodalities of all Pascal generalised rays are determined by showing that the sequence wk $=\binom{n+\alpha k}{m+\beta}_q$ is log concave, then unimodal.

The Fibonaccci polynomials:Notes that if k is a real variable of x, then Fk;n = Fx;n is the polynomials defined by Fibonacci,

$$Fn+1(x)=\begin{cases}1 & \text{if } n=0\\ x & \text{if } n=1\\ xF_n(x)+F_{n-1}(x) & \text{if } n\geq 2\end{cases}$$

from where The first polynoms of Fibonacci are

$F_1(x)=1$

$F_2(x)=x$

$F_3(x)=x^2+1$

$F_4(x)=x^3+2x$

$F_5(x)=x^5+4x^3+3x$

And more it can write k-Fibonacci numbers from these expressions:

$$Fn+1(x)=\sum_{l=0}^{\lfloor n/2\rfloor}\binom{n-i}{l}x^{n-2i} \quad \text{for } n\geq 0$$

Notice is that F2n(0) = 0 and x = 0is the only real root, while F2n+1(0)=1 to with no real roots.

Also for x = k2N The k-Fibonacci sequence elements are obtained.

Analysis: Chebyshev polynomials show integral representations of the hermit polynomials and the generation process will add the new representations of Chebyshev polynomials. Chebyshev polynomials after the second kind $U_n(x)$

$$U_n(x)=\sum_{k=0}^{\lfloor n/2\rfloor}\frac{(-1)^k(n-k)!(2x)^{n-2k}}{k!(n-2k)!}$$

Proposition 1. The two polynomials of Chebyshev satisfy the following integral characterization:

$$U_n(x)=\frac{1}{n!}\int_0^{+\infty}e^{-t}t^nH_n(2x,-\frac{1}{t})dt$$

Proof: By taking note of this

$$n!=\int_0^{\infty}e^{-t}t^ndt$$

It can write as

$$(n-k)! = \int_0^{\infty} e^{-t} t^{n-k} dt$$

The explicit form of $U_n(x)$ the Chebyshev polynomials, and the standard two-variable Hermit polynomials:

We know that

$$H_n(x,y) = n! \sum_{k=0}^{\left\lfloor \frac{n}{2} \right\rfloor} \frac{(y)^k (x)^{n-2k}}{k!\,(n-2k)!} \tag{2.1}$$

$$U_n(x) = \sum_{k=0}^{\left[\frac{n}{2}\right]} \frac{(-1)^k\,(n-k)!\,(2x)^{n-2k}}{k!\,(n-2k)!} \tag{2.2}$$

$$In\ (2.1)\ x\ repalce\ by\ 2x\ and\ y\ replace\ by\ -\frac{1}{t}\ \ we\ will\ get$$

$$H_n\left(2x, -\frac{1}{t}\right) = n! \sum_{k=0}^{\left\lfloor \frac{n}{2} \right\rfloor} \frac{(-1)^k (2x)^{n-2k} t^{-k}}{k!\,(n-2k)!} \tag{2.3}$$

Now (2.3) multiplying both side by $e^{-t}t^n\ and\ integrating\ limit\ 0\ to\ \infty$

We will get

$$\int_0^{\infty} e^{-t} t^n\, H_n\left(2x, -\frac{1}{t}\right) dt = n! \sum_{k=0}^{\left\lfloor \frac{n}{2} \right\rfloor} \frac{(-1)^k (2x)^{n-2k}}{k!\,(n-2k)!} \int_0^{\infty} e^{-t}\, t^{n-k} dt \tag{2.4}$$

$$using\ (n-k)! = \int_0^{\infty} e^{-t} t^{n-k} dt\ \ in\ (2.4)\ \ we\ will\ get$$

$$\int_0^{\infty} e^{-t} t^n H_n\left(2x, -\frac{1}{t}\right) dt = n! \sum_{k=0}^{\left\lfloor \frac{n}{2} \right\rfloor} \frac{(-1)^k (2x)^{n-2k} (n-k)!}{k!\,(n-2k)!}$$

So we have

$$U_n(x) = \frac{1}{n!} \int_0^{+\infty} e^{-t} t^n H_n(2x, -\tfrac{1}{t}) dt$$

and then the study.

Theorem 2: The Chebyshev polynomials $T_n(x)$ and $U_n(x)$ satisfy the following recurrence relations:

$$\frac{d}{dx} U_n(x) = nW_{n-1}(x)$$

$$U_{n+1}(x) = xW_n(x) - \frac{n}{n+1} W_{n-1}(x)$$

Where,

$$W_n(x) = \frac{2}{(n+1)!} \int_0^{+\infty} e^{-t} t^{n+1} H_n(2x, -\tfrac{1}{t}) dt.$$

Proof- In the above section the recurring relations of the standard hermit polynomials $H_n(x, y)$ can be costumed as follows.

First we will prove identity (2.5) and (2.6)

$$\left[2x + \frac{1}{-t} \frac{\partial}{\partial x}\right] H_n(2x, \tfrac{1}{-t}) = H_{n+1}(2x, -\tfrac{1}{t}) \tag{2.5}$$

$$\frac{1}{2} \frac{\partial}{\partial x} H_n(2x, -\tfrac{1}{t}) = n\, H_{n-1}(2x, -\tfrac{1}{t}) \tag{2.6}$$

Consider

$$\frac{\partial H_n(2x, -\frac{1}{t})}{\partial x} = n! \sum_{k=0}^{\left\lfloor \frac{n-1}{2} \right\rfloor} \frac{2(-1)^k (2x)^{n-2k-1} (n-2k) t^{-k}}{k!(n-2k)!}$$

$$\frac{\partial H_n(2x, -\frac{1}{t})}{2\partial x} = n! \sum_{k=0}^{\left\lfloor \frac{n-1}{2} \right\rfloor} \frac{(-1)^k (2x)^{n-2k-1} t^{-k}}{k!(n-2k-1)!}$$

So we have

$$\frac{1}{2} \frac{\partial}{\partial x} H_n(2x, -\tfrac{1}{t}) = n\, H_{n-1}(2x, -\tfrac{1}{t})$$

So (2.6) has proved some process we can prove (2.5)

By above theorem we have

$$U_n(x) = \frac{1}{n!}\int_0^{+\infty} e^{-t}t^n H_n(2x, -\frac{1}{t})dt$$

Differentiation both side with respect to we get

$$\frac{d}{dx}U_n(x) = \frac{1}{n!}\int_0^{+\infty} e^{-t}t^n \frac{\partial}{\partial x}H_n(2x, -\frac{1}{t})\,dt$$

Now using identity (2.5) we will get

$$\frac{d}{dx}U_n(x) = \frac{2n}{n!}\int_0^{+\infty} e^{-t}t^n H_{n-1}(2x, -\frac{1}{t})\,dt \qquad (2.7)$$

The relation above provides a link between polynomials $T_n(x)$ and $U_n(x)$ however, as:

$$U_{n-1}(x) = \frac{1}{(n-1)!}\int_0^{+\infty} e^{-t}t^{n-1} H_{n-1}(2x, -\frac{1}{t})dt \qquad (2.8)$$

Using (2.8) in (2.7) immediately get:

$$\frac{d}{dx}T_n(x) = nU_{n-1}(x).$$

By using Second kind of Chebyshev polynomials in the first identity

$$U_{n+1}(x) = \frac{1}{(n+1)!}\int_0^{+\infty} e^{-t}t^{n+1} H_{n+1}(2x, -\frac{1}{t})dt$$

Using $\left[2x + \frac{1}{-t}\frac{\partial}{\partial x}\right]H_n(2x, \frac{1}{-t}) = H_{n+1}(2x, -\frac{1}{t})$ in (2.9)

$$U_{n+1}(x) = \frac{1}{(n+1)!}\int_0^{+\infty} e^{-t}t^{n+1}\left[2x + \frac{1}{-t}\frac{\partial}{\partial x}\right]H_n(2x, -\frac{1}{t})dt$$

That is

$$U_{n+1}(x) = x\frac{2}{(n+1)!}\int_0^{+\infty} e^{-t}t^{n+1} H_n(2x, -\frac{1}{t})dt - \frac{1}{(n+1)!}\int_0^{+\infty} e^{-t}t^n \frac{\partial}{\partial x}H_n(2x, -\frac{1}{t})dt \qquad (2.10)$$

Using $\frac{1}{2}\frac{\partial}{\partial x}H_n(2x, -\frac{1}{t}) = n\,H_{n-1}(2x, -\frac{1}{t})$ in (2.10)

We have

$$U_{n+1}(x) = x\frac{2}{(n+1)!}\int_0^{+\infty} e^{-t}t^{n+1} H_n(2x, -\frac{1}{t})dt - \frac{2n}{(n+1)!}\int_0^{+\infty} e^{-t}t^n H_{n-1}(2x, -\frac{1}{t})\,dt \qquad (2.11)$$

Using $W_n(x) = \frac{2}{(n+1)!}\int_0^{+\infty} e^{-t}t^{n+1} H_n(2x, -\frac{1}{t})dt$ in (2.11) we have

$$U_{n+1}(x) = xW_n(x) - \frac{n}{n+1}W_{n-1}(x)$$

Also we have

$$\frac{d}{dx}U_n(x)=\frac{2n}{n!}\int_0^{+\infty} e^{-t}t^n H_{n-1}(2x,-\frac{1}{t})\,dt$$

And

$$W_n(x)=\frac{2}{(n+1)!}\int_0^{+\infty} e^{-t}t^{n+1}H_n(2x,-\frac{1}{t})dt$$

$$Replace\ n+1\ by\ n$$

We get

$$W_{n-1}(x)=\frac{2}{(n)!}\int_0^{+\infty} e^{-t}t^{n}H_{n-1}(2x,-\frac{1}{t})dt$$

So we have

$$\frac{d}{dx}U_n(x)=\text{n } W_{n-1}(x)$$

Generation of functions: The first and second type of Chebyshev polynomials can draw a slightly different links from these polynomials and their generative functions using the integrated representations in the previous section and related recurrence relations.

For the $U_n(x)$ Polynomials of Chebyshev, we notice that both sides of the equation by $\xi^n\,|\xi|<1$ and it follow by sum marizing over n

$$\sum_{n=0}^{+\infty}\xi^n\,U_n(x) = \int_0^{+\infty} e^{-t}\sum_{n=0}^{+\infty}\frac{(t\xi)^n}{n!}H_n(2x,-\frac{1}{t})dt$$

By remembering the polynomials of the $\sum_{n=0}^{+\infty}\frac{t^n}{n!}H_n(x,y) = e^{(xt+yt^2)}$ in the above relation generation and t integration, we end.

$$\sum_{n=0}^{+\infty}\xi^n\,U_n(x)=\frac{1}{1-2\xi x+\xi^2}.$$

By using the results seen in the previous theorem, we can now state the respective generation function for the first Chebyshev polynomial $T_n(x)$ and $U_n(x)$

IV. APPLICATIONS OF RECURRENCE RELATIONS

- *Biology*

Some of the most recognised variability calculations arise in attempts to shape population dynamics. The Fibonacci numbers, for examples, were once utilised as an example of growing the population of rabbit.Integrodifference equations are a significant type of recurrent relationship to spatial ecology. This and other variability computations are especially suitable for modelling in univoltine populations.

- *Computer Science*

Recurrence relation is also an important value in algorithm analysis. If an algorithm is intended to break a problem into more low (the divide and conquer) problems it run at times will be described by a relationship repetition.Simpler instances are that it takes the time and find an item with n elements in the order vector (in case no components can take such a density).One component at a time, from left to right, will be sought with a native algorithm. The worst case would be where the desired substance is the last element, so the range of contrasts is n.Binary search is the better algorithm. It takes a single, ordered vectors. That checks whether the element is in centre of the vector first. If not, then whether the centre component is greater than or less than the desired component is monitored.

- *Digital Signal Processing*

Digital signal processors) is the digital processing method for a wide variety of signal processing activities, as on the part of computer machines or more specialised digital signal processors. The digit this way is a set of numbers that is a series of digits forming samples of a continuous variable in a particular domain such as time, area, space, or frequency in this order. In digital signal processing, repetition links may impact feedback in a process where outputs, at the same time, become products. Thus, they occur in digital filters of infinite impulse response (IIR).Multi-use improvements can enhance the cryptographic safety of digital signals the encrypted and decrypted algorithms.

- *Economics*

In both theoretical and empirical economies, recurrent relationships, particularly straight recurrence interactions, are widely used. On a macroeconomic stage in particular, a model regions of big economy (the financial sector, the commodity area and the labour market etc.) might be developed based in that some actors' action depends on lagging trend modalities. You would be willing to solve the model to fix main variables' current value with regard to past and actual values (interest rate, true GDP, etc.) in other variables.23 .

- *Network Marketing*

Network business is a business method or activity in which people are compensated for not only work created by themselves, but for the work also produced by others. "The network business model is referred to as "down line model," since it is developed by distributors with multiple levels of compensation and "several" levels in.

All sorts of network enterprise platforms are there. Employees directly sell products to customers through link referrals and word of voice marketing in most network business platforms. Many grid marketing organizations aimed to build opportunities for individuals who would not otherwise have them, including those who. Less privacy in running their own company, Do not have limited cash, Compatible with their present labor level, Has been unwise with own companies failed to work. Recurrence is a very helpful subject in mathematics which resolves many issues of real lives many through repeated interactions.

A lot of individuals are involved in network marketing companies in modern time Network Marketing is very renowned company direction·

V. CONCLUSION

Recurrence relation is very useful topic of mathematics many problems of real life many be solved by recurrence relations but in recurrence relation there is a major difficulty in the recurrence relation if we want find 100th term of sequence then we need to find all previous 99 terms of given sequence then we can get 100th term of sequence but above theorem is very useful if coefficients of recurrence relation of given sequence are satisfied the condition of the above theorem then we can apply above theorem and we can find direct any term of sequence without find all previous terms. There is important property of a relation between coefficients of recurrence relation terms and roots of a polynomial for second order relation but in this paper, we gave this same property of recurrence relation of all higher order recurrence relation. So finally, we can say that this theorem is valid all order of recurrence relation only condition that roots are distinct. So, we can say that this paper is generalization of property of a relation between coefficients of recurrence relation terms and roots of a polynomial.

The relation between primary numbers and perfect numbers, including composite numbers, exists.

The first term will be 2 × 2 = 4, next 2 × 3 = 6, 3 × 3 = 9, etc. in composite numbers by means of primaries; 2, 3,5,7,11,13,17,19,23,29,31 etc. and by means of a composite count number, in line with the formula for m and n composites, where m and n shall be both primarily numbers. The processing is such that there is no number between them, such as 3x3, and multiply 2 by 5, to get 10. However, it is laborious to achieve composite numbers that are far-reaching, so that the nth composite number (Cn) can be produced with the Wolfram Language Code as above. It is a code for the computer. A manual algorithm for extrapolating large composite numbers is exceedingly difficult to develop. But the generating function of Dirichlet is used for the characteristic function of the composite numbers. The relationship can also be dealt with as follows in ideal numbers; (Power of Two) × (Double that Power - 1). The prime number formula is given by (2n-1). To get the Perfect Number, the formula becomes (2n-1) × (2n-1). Getting the nth sequence of a perfect number is dependent on the equivalent nth sequence of prime numbers. The research finally concludes with the call for researchers to team up to make more explicit, the recurrence relation in composite numbers. The study focuses its intention on recurrence relation in perfect and composite numbers. It is hinged at analyzing the mathematical relationships between them, as well as asking new questions about them and to prove that these relationships are true.

Recurrence Relation of Network Marketing is the sector came into being, marketing has become one of the main data mining applications. The determination whether a specific individual is to advertise is usually based solely on its characteristics or those of the population segments to which they belong (direct marketing) (mass marketing). This also results in optimum targeting choices since the impact of a business consumers on each other's buying decisions is not taken into consideration. Customers are heavily affected by the views of their partners in many markets. Viral marketing does this to sell a commodity cheaply, mostly through marketing people with the highest consumer power.

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