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# Effect of household processing on reduction of pesticide residues in Bringal (Eggplant, Solanum melongena)

**Neha Thanki[1], Praful Joshi[2] and Hasmukh Joshi*[1]**

*[1]Smt. S. B. Gardi Institute of Home Science, Saurashtra University, Rajkot, India*
*[2]Office of the Director of research, Anand Agril. Uni, Anand, India*

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**ABSTRACT**

*Eggplant is cultivated largely on small landholdings where sale of its produce from a frequent picking through the prolonged harvest season generates valuable cash income to farmers. In the hot-wet monsoon season, when other vegetables are in short supply, eggplant is practically the only vegetable that is available at an affordable price for rural and urban poor. Traditionally eggplant is eaten in the form of subji and roasted form known as bharatha or orro. Therefore, raw, cooked and roasted form of eggplant was selected for the study. Literature reveals that vegetables may contain pesticide residues above the prescribed maximum residue levels (MRL), which may pose health hazard to the consumers. Analysis of eggplant for pesticidal contamination was carried out on Gas Chromatograph-Electron Capture and TID Detector with capillary columns. Eggplant was found contaminated with monocrotophos, phorat, quinalphos, pendamethalin, carbaryl, p,p' DDT, endosulphan, p,p' DDD, captafol, permethrin and cypermethrin It can be concluded that residues of monocrotophos exceeded their respective maximum residue limits and it is decontaminated by cooking and roasting process. Processing substantially lowers the residues of pesticides in eggplant. The present study showed that roasting was found more effective than cooking.*

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## INTRODUCTION

Vegetables are essential components of our diet due to their nutritional value. Fruits, nuts, and vegetables play a significant role in human nutrition, especially as sources of vitamins (C, A, B6, thiamine, niacin, E), minerals, and dietary fiber [1-3]. In near future, there is a need of around 5-6 million tones of vegetables to feed over 1.3 billion Indian population expected by the year 2020 [4]. The total area under vegetables crops is 71, 31, 000 hectares with total annual production of 11, 01, 06000 tonnes [5, 6]. However, several factors limit their productivity, mainly insect pests and diseases, due to increased pest menace there is an average loss of 40% in different crops [7]. Eggplant, *Solanum melongena* L., is a typical vegetable crop in that its cultivation helps to generate income for farmers, yet it also degrades the environment largely due to heavy use of pesticides, especially in Asia. This crop is especially important in South Asia, where it is one of the three most widely grown vegetable species. This region accounts for almost 50% of the world's eggplant production. The major eggplant producing states are West Bengal, Orissa, Bihar, and Gujarat. 1236.27, 1143.6 and 1046.26 tones eggplant produced by Gujarat state during 2010-11, 2009-10 and 2008-09 respectively (Source: National Horticulture Board; NHB).The major pests are root-knot nematodes in infested soils, and red spider mite, particularly under warm, dry conditions. Other pests, such as cutworm and American bollworm are often problems. Tip-wilters, leaf-eating beetles, and various aphids also occur. In order to combat the insect pest problem, lot of pesticides is used by the vegetable growers for better yield and quality. Insecticides are repeatedly applied during the entire period of growth and sometimes even at the fruiting stage. It accounts for 13-14% of total pesticide consumption as against 2.6% of cropped area [8]. Pesticide exposure has been associated with human health risk of arthritis, skin disease, bone disorder, cancer and nerve disorder [9, 10]. Indiscriminate use of pesticides particularly at fruiting stage and non adoption of safe waiting period leads to accumulation of pesticides residues in consumable vegetables. Contamination of vegetables with pesticide residues has been reported by many researchers [11-13]. Scientists and food processors have long been interested in the effect of processing on pesticide residues in food commodities. The extent to which pesticide residues are removed by processing depends on a variety of factors, such as chemical properties of the pesticides, the nature of food commodity, the processing step and the length of time the compound has been in contact with the food [14-16]. The presence of pesticide residues is a major bottleneck in the international trade of food commodities.

Eggplant is cultivated largely on small landholdings where sale of its produce from a frequent picking through the prolonged harvest season generates valuable cash income to farmers. In the hot-wet monsoon season, when other vegetables are in short supply, eggplant is practically the only vegetable that is available at an affordable price for rural and urban poor. Traditionally eggplant is eaten in the form of subji and roasted form known as bharatha or orro. Therefore, raw, cooked and roasted form of eggplant was selected for the study. The objective of this study is to investigate the effect of some processes like roasting and cooking on reduction of pesticide residues on eggplant.

## MATERIALS AND METHODS

Samples of eggplant were commercially purchased from the market of Rajkot city, Gujarat, India and served as the blank or spiked sample. All the samples were extracted fresh. In order to assess the effects of household processing like roasting and cooking one part of the sample of eggplant was roasted on direct flame. The other parts of the unwashed sample was mixed with 100 ml water and cooked. The roasted and cooked samples were then processed in a manner similar to that of the unprocessed (Raw) samples. For the purpose of spiking and quantification, the reference materials of pesticides which were >98% pure were procured from RFCL, Delhi, India. The standard stock solutions (100 ppm) were prepared in ethyl acetate and stored at $-4^0$C. HPLC grade hexane, acetone and ethyl acetate, and AR grade anhydrous sodium sulphate, sodium chloride were also procured from RFCL, Delhi, India. Mechanical shaker (Modern Industrial corporation, Bombay, India), blender (Boss Appliances, Daman, India), centrifuge, (Kumar Industries, Bombay, India), and rotary evaporator (Jain Scientific, India) were used.

**Pesticide Standards**: Stock solution of each pesticide was prepared at 1000 μg/ml in ethyl acetate. Working standard mixtures of eleven pesticides in ethyl acetate, containing 1μg/ml of each pesticide, were used for spiking the samples and preparing calibration standards.

### Extraction

Commercially purchased eggplant served as the blank or spiked sample. All the samples were extracted fresh. Each vegetable was chopped into small pieces and after quartering, a representative sample (50g) was macerated with 5-10g anhydrous sodium sulphate in Warring blender to make a fine paste. The macerated sample was extracted with 100ml acetone on mechanical shaker for 1 h by using the method of Kumari *et al.* (2001) [17]. Extract was filtered, concentrated up to 40ml and subjected to liquid-liquid partitioning with ethyl acetate (50, 30, 20 ml) after diluting 4-5 times with 100 ml 10% aqueous NaCl solution. Concentrated the organic phase up to 10ml on rotary evaporator and divide it into two equal parts. One part was kept for OC and second for OP.

### Clean-up

For OC, clean-up was carried out by using column chromatography. Column (60cm × 22mm) was packed with, Florisil and activated charcoal (5:1 w/w) in between the two layers of anhydrous sodium sulphate. Extract was eluted with 125ml mixture of ethyl acetate: hexane (3:7 v/v). Eluate was concentrated to 2ml for residue analysis.

Residues of OP were also cleaned by adopting column chromatographic technique. Column was packed with silica gel and activated charcoal (5:1 w/w) in between the layers of anhydrous sodium sulphate. Extract was eluted with 125ml mixture of acetone: hexane (3:7 v/v). After concentrating the eluate on rotary evaporator, final volume was made to 2ml for analysis by gas liquid chromatography (GC).

**Estimation**

The cleaned extracts were analyzed on Thermofisher 1000 GC equipped with capillary columns using $^{63}$Ni electron capture detector (ECD) and TID. Operating conditions were as per details: For OC: Detector : ECD ($^{63}$Ni), column: SPB-5 of 5% diphenyl/ 95% dimethyl fused silica capillary column (30 m×0.32 mm ID, 0.25 $\mu$m film thickness) with split system. Temperatures ($^{0}$C):150 (5 min) → 8 $^{o}$c min$^{-1}$ → 190 (2 min) → 15 $^{o}$c min$^{-1}$ 280°c (10 min); injection port: 280 $^{o}$c; detector: 300 $^{o}$c; carrier gas: ($N_2$), flow rate 60 ml min$^{-1}$, 2 ml through column and split ratio 1:10. Carrier gas, $N_2$, flow rate 60 ml min$^{-1}$, 2 ml through column.

For OP: Detector: TID, megabore column: HP-1 of methyl silicone (10 m×0.53 mm ID, 2.65 $\mu$m film thickness). Temperatures($^{0}$C): Oven: 100 (1 min) → 10 $^{o}$c min$^{-1}$ → 200 $^{o}$c (0 min ) → 20 $^{o}$c min$^{-1}$ → 260 $^{o}$c (3 min); injector port, 250 $^{o}$c , detector, 275 $^{o}$c , carrier gas $N_2$ 18 ml min$^{-1}$, $H_2$, 1.5 ml min$^{-1}$ and zero air 130 ml min$^{-1}$.

## RESULTS AND DISCUSSION

The average percent recoveries at the spiking levels of 1µg/ml of each pesticide were in the range of 80–110. The data collected during this study is presented in Tables 1 & 2. In the analyzed samples, the detected pesticides comprised of monocrotophos, phorat, quinalphos, pendamethalin, carbaryl, p,p' DDT, endosulphan, p,p' DDD, captafol, permethrin and cypermethrin. In India, DDT has been banned with effect from April 1993. Practically, DDT is not phased out completely because it is still used to control the mosquito in public health programmes from where it could enter the agricultural soils and water systems and possibly find its way into crops. Presence of endosulfan in the present study is due to use of endosulfan in almost every crop in Gujarat, India among the OC pesticides after banning of use of DDT and HCH in 1993. The study revealed that eggplant was found contaminated with all the pesticides. Only residue of monocrotophos exceeded the MRL value. The results obtained from the present study are consistent with earlier studies that show residues of these pesticides are present in different vegetables [11-13, 18-20].

**Table-1: Pesticide residues* (µg g$^{-1}$) in eggplant**

| Sr no | Pesticide | Raw | | | | | Cooking | | | | | Roasting | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Monocrotophos | 48.38 | 38.38 | 43.28 | 30.21 | 44.4 | 31.0 | 21.0 | 30.5 | 30.8 | 30.6 | 32.11 | 22.31 | 27.32 | 30.21 | 28.18 |
| 2 | Phorate | 0.81 | 0.91 | 0.85 | 0.83 | 0.79 | 0.28 | 0.38 | 0.32 | 0.28 | 0.26 | 0.26 | 0.36 | 0.30 | 0.28 | 0.24 |
| 3 | Quinalphos | 0.24 | 0.34 | 0.26 | 0.22 | 0.21 | 0.19 | 0.29 | 0.21 | 0.13 | 0.16 | 0.15 | 0.25 | 0.17 | 0.13 | 0.12 |
| 4 | pendamethalin | 0.69 | 0.79 | 0.71 | 0.67 | 0.66 | 0.44 | 0.54 | 0.46 | 0.04 | 0.41 | 0.05 | 0.06 | 0.03 | 0.04 | 0.02 |
| 5 | Carbaryl | 3.42 | 4.42 | 3.44 | 3.4 | 3.39 | 1.27 | 2.27 | 1.29 | 2.25 | 3.39 | 1.04 | 2.04 | 1.06 | 1.01 | 1.00 |
| 6 | Pp DDT | 0.0041 | 0.004 | 0.0035 | 0.003 | 0.0025 | 0.003 | 0.003 | 0.0025 | 0.002 | 0.005 | 0.002 | 0.002 | 0.0015 | 0.0014 | 0.001 |
| 7 | Endosulphan-II | 1.38 | 1.4 | 1.42 | 1.34 | 1.28 | 0.52 | 0.54 | 0.5 | 0.48 | 0.40 | 0.13 | 0.16 | 0.11 | 0.12 | 0.10 |
| 8 | P p DDD | 0.25 | 0.27 | 0.29 | 0.23 | 0.21 | 0.24 | 0.26 | 0.28 | 1.22 | 0.20 | 0.02 | 0.01 | 0.03 | 0.015 | 0.014 |
| 9 | Captafol | 0.38 | 0.40 | 0.42 | 0.36 | 0.34 | 0.25 | 0.27 | 0.29 | 0.23 | 0.21 | 0.05 | 0.04 | 0.045 | 0.03 | 0.025 |
| 10 | Permethrin | 0.16 | 0.17 | 0.18 | 0.15 | 0.14 | 0.12 | 0.13 | 0.14 | 0.11 | 0.10 | 0.06 | 0.05 | 0.04 | 0.03 | 0.028 |
| 11 | Cypermethrin | 0.20 | 0.21 | 0.22 | 0.19 | 0.18 | 0.12 | 0.13 | 0.14 | 0.11 | 0.10 | 0.10 | 0.11 | 0.12 | 0.09 | 0.08 |

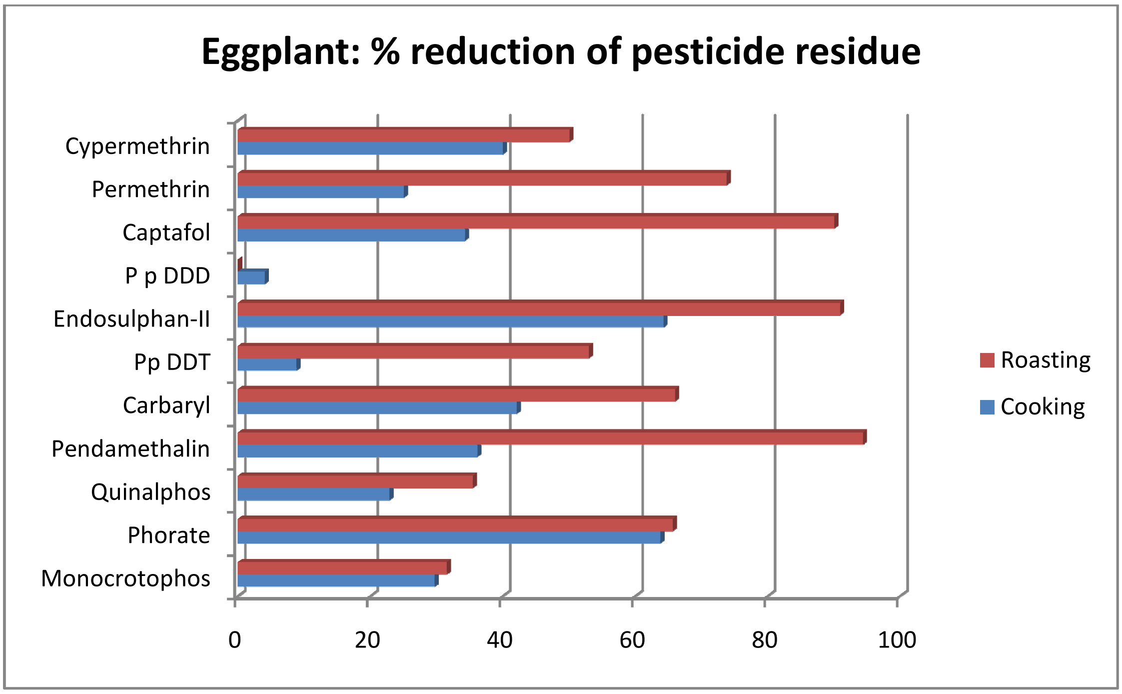
**Effects of household processing**

Among household processes cooking process reduced the pesticide residues by 4.0-85.78 percent. Maximum reduction of residue was observed in case of monocrotophos and endosulphan where the residues decreased to the extent of 85.78 and 64.22 percent by cooking process respectively. In the present study cooking was found effective in the decontamination of pesticide residues as it depends on a number of factors like, location and age of residues, water solubility, temperature and type of washing solution. In earlier studies also, effect of these factors were observed in different vegetables by various researchers [11-13, 18-20]. Cooking found comparatively less effective in reducing the residues of quinalphos (22.84%), p,p' DDT (8.82%) and p,p' DDD (4.0%).

Roasting was observed to be more effective in reducing the residues. By this process, reduction of residues of eleven pesticides was observed in the range of 35.43-94.32 percent. The great variation in reduction of residues by roasting was observed which may be attributed to the rates of degradation and volatilization of residues as the concentration of residues increases by heat involved in roasting. Maximum reduction was observed in the case of pendamethalin, p,p' DDD, endosulphan-II, monocrotophos, and captafol where the residues decreased to the extent of 94.32, 92.8, 90.91, 90.26 and 90.0 percent respectively. Holland *et al.*, (1994) [15] reported appreciably reduction in pesticide residues in different commodities by using different processing methods. Hence, the present results are in consistent with the earlier results [11-13, 18,- 20].

**Table-2: Effect of processing on pesticide residues ($\mu g\ g^{-1}$) in eggplant**

| Sr. no | Name of Pesticide | Raw Range (Mean) | Cooking Range (Mean) [% Reduction] | Roasting Range (Mean) [% Reduction] |
|---|---|---|---|---|
| 1 | Monocrotophos | 30.21-48.93 (40.93) | 21.0-30.5 (28.78) [29.68] | 22.31-32.11 (28.03) [31.52] |
| 2 | Phorate | 0.79-0.91 (0.838) | 0.26-0.38 (0.304) [63.72] | 0.24-0.36 (0.288) [65.63] |
| 3 | Quinalphos | 0.21-0.34 (0.254) | 0.13-0.29 (0.196) [22.84] | 0.12-0.25 (0.164) [35.43] |
| 4 | Pendamethalin | 0.66-0.79 (0.704) | 0.40-0.54 (0.45) [36.08] | 0.02-0.06 (0.04) [94.32] |
| 5 | Carbaryl | 3.39-4.42 (3.614) | 1.27-3.39 (2.094) [42.06] | 1.00-2.04 (1.23) [65.97] |
| 6 | Pp DDT | 0.003-0.0041 (0.0034) | 0.002-0.005 (0.0031) [8.82] | 0.001-0.002 (0.0016) [52.94] |
| 7 | Endosulphan-II | 1.28-1.42 (1.364) | 0.40-0.54 (0.488) [64.22] | 0.10-0.16 (0.124) [90.91] |
| 8 | P p DDD | 0.21-0.29 (0.25) | 0.20-0.28 (0.24) [4.00] | 0.01-0.03 (0.018) [92.8] |
| 9 | Captafol | 0.34-0.42 (0.38) | 0.21-0.29 (0.25) [34.21] | 0.03-0.05 (0.038) [90.00] |
| 10 | Permethrin | 0.14-0.18 (0.16) | 0.10-0.14 (0.12) [25.00] | 0.28-0.06 (0.042) [73.75] |
| 11 | Cypermethrin | 0.18-0.22 (0.20) | 0.10-0.14 (0.12) [40.00] | 0.08-0.12 (0.10) [50.00] |




## CONCLUSION

It can be concluded that residues of monocrotophos exceeded their respective maximum residue limits and it is decontaminated by cooking and roasting process. Processing substantially lowers the residues of pesticides in eggplant. The percentage reductions in the present study are supported by both early and most recent publications. These reductions are extremely important in evaluating the risk associated with ingestion of pesticide residues, especially in vegetables, which are eaten by almost all income groups' people. The present study showed that roasting was found more effective than cooking.

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