

SHORT COMMUNICATIONS

OSMIC ACID AS A COLORIMETRIC REAGENT FOR THE DETERMINATION OF ASCORBIC ACID

ABDUL MAJID NADIM AND
MAHMOOD-UL-HASSAN

*West Regional Laboratories, Pakistan Council of
Scientific and Industrial Research, Lahore*

(Received January 25, 1965)

Introduction

Ascorbic acid (Vitamin C) can be determined by (1) colorimetric methods, (2) titrimetric methods and (3) biological methods. In the colorimetric methods reagents most widely used include uranium nitrate,¹ phospho-tungstic acid,² 2,4-dinitrophenylhydrazine³⁻⁵ and ferridipyridyl.⁶

The titrimetric methods are based on the application of reagents such as iodine, methylene blue,^{7,8} ferricyanide,⁹ 2,6-dichlorophenol-indophenol,¹⁰ and N-bromsuccinimide.¹¹

In the present paper, a colorimetric method is reported which is based on a colour reaction of ascorbic acid with osmic acid. The method is suitable for quick determination of vitamin C in pharmaceuticals and test solutions.

Experimental

Apparatus.—Lange photoelectric colorimeter Model IV.

Chemicals.—0.01 percent ascorbic acid solution prepared by dissolving A.R. grade ascorbic acid in water; 0.1 percent osmic acid solution prepared by dissolving the acid in water; buffer solution prepared by dissolving 3.4g. of KH_2PO_4 and 8.954g. of Na_2HPO_4 in 1 litre of distilled water. The solution maintains the pH at 7.0.

Procedure

Determination of Vitamin C in Test Solutions.—(A). A volume of the ascorbic acid solution containing not less than 300 μg of ascorbic acid was diluted to 12.5 ml. with distilled water. 10 ml. of the buffer solution, followed by 2.5 ml. of the osmic acid solution, were added to the diluted ascorbic

acid solution. The colour was allowed to develop for 14 minutes and the solution was then diluted to 100 ml. Absorbance of the solution was measured in the colorimeter. The whole sequence of operations, from the time osmic acid was added till the measurement of absorbance, was completed in 15 minutes.

The absorbance was measured with different amounts of ascorbic acid and a standard curve was drawn between absorbance and concentration of ascorbic acid.

(B). The above procedure was repeated but dilution to 100 ml. was made just after the addition of osmic acid and the absorbance was recorded 15 minutes after the addition of osmic acid. The relationship between absorbance and concentration was found to be linear.

Determination of Vitamin C in Pharmaceutical Tablets.—Ten tablets were weighed and powdered. An accurately weighed quantity of the powder was dissolved in water and the volume made to 100 ml. The solution contains 0.1 mg. of the powder in 1 ml. Vitamin C was determined in the sample using 3-5 ml. of the solution.

Results and Discussion

Ascorbic acid solutions of different strengths were prepared and their acid content determined by the proposed method (Table 1). It is observed (Table 2) that ascorbic acid can be reliably estimated by this method which is comparable with a titrimetric method based on N-bromsuccinimide.

The method is based on the selective colour reaction of ascorbic acid with osmic acid and the colour produced is measured expeditiously with a colorimeter. The colour formation of ascorbic acid with osmic acid is quite sensitive and this method has no stringent conditions attendant upon it. The method is workable for test solutions as well as for pharmaceuticals (Table 3). Many interferences have been checked which show that oxalates, starch, sucrose, lactose and glucose do not interfere. However, the application of this colour reaction still needs to be extended to the determination of the vitamin in fruits and vegetables.

TABLE 1.—COLORIMETRIC DETERMINATION OF ASCORBIC ACID (VITAMIN C) USING OSMIC ACID IN TEST SOLUTIONS.

| Ascorbic acid present μg. | Ascorbic acid as determined by | | Error % |
|------------------------------|--------------------------------|-------------|---------|
| | Procedure A | Procedure B | |
| | μg. | μg. | |
| 300 | 305 | — | 1.66 |
| 320 | 320 | 320 | 0.00 |
| 330 | 330 | 330 | 0.00 |
| 400 | 405 | 405 | 1.25 |
| 425 | 430 | — | 1.16 |
| 430 | — | 427.5 | 0.57 |
| 475 | 476.25 | — | 0.26 |
| 480 | 477 | — | 0.625 |
| 510 | — | 512.5 | 0.49 |
| 525 | 525 | — | 0.00 |
| 575 | 573 | — | 0.35 |
| 590 | — | 587.25 | 0.38 |
| 600 | 595 | — | 0.83 |

TABLE 2.—COMPARISON OF RESULTS BY OSMIC ACID AND N-BROMSUCGINIMIDE (N.B.S.).

| Ascorbic acid present μg. | Found by osmic acid μg. | Error % | Found by N.B.S. μg. | Error % |
|------------------------------|----------------------------|---------|------------------------|---------|
| 300 | 305 | 1.66 | 306 | 2.00 |
| 320 | 320 | 0.00 | 316 | 1.25 |
| 400 | 405 | 1.25 | 395 | 1.25 |
| 425 | 430 | 1.16 | 422 | 0.7 |
| 475 | 477 | 0.42 | 474 | 0.21 |
| 525 | 525 | 0.00 | 516 | 1.71 |
| 550 | 550 | 0.00 | 544 | 1.1 |
| 575 | 577.5 | 0.44 | 562 | 1.9 |
| 600 | 598 | 0.33 | 593 | 1.1 |

TABLE 3.—ESTIMATION OF ASCORBIC ACID IN TABLETS BY 0.1% OSMIC ACID SOLUTION.

| Sample | Ascorbic acid present μg. | Ascorbic acid determined μg. | Error % |
|--------|------------------------------|---------------------------------|---------|
| Tablet | 300 | 303.5 | 1.16 |
| | 350 | 354 | 1.14 |
| | 400 | 406 | 1.25 |

References

1. M.Z. Barakat, N. Badran, and S.K. Shehab, *J. Pharm. Pharmacol.*, **4**, 46 (1952).
2. Fujita and Ebihara, *Biochem. Z.*, **182**, 192, 290 (1937).
3. J.H. Roe, and C. Kuether, *J. Biol. Chem.*, **147**, 399 (1943).
4. J.H. Roe, M.B. Mills, M.J. Oesterling, and C.M. Damron, *J. Biol. Chem.*, **174**, 201 (1948).
5. J.H. Roe, and M.J. Oesterling, *J. Biol. Chem.*, **152**, 511 (1944).
6. Schiefelbusch Koeing, and Johnson, *Ind. Eng. Chem. Anal. Ed.*, **15**, 181 (1943).
7. Imre Gal, *Nature*, **138**, 799 (1936).
8. J.Z. Tillmans, *Z. Lebensm. Untersuch.*, **54**, 33 (1927).
9. H. Tauber, and I.S. Kleiner, *J. Biol. Chem.*, **108**, 563 (1935).
10. O.A. Bessey, and C.G. King, *J. Biol. Chem.*, **103**, 687 (1933).
11. M.Z. Barakat, M. Fathy and M.M. El-Sadr, *Anal. Chem.*, **27**, 536 (1955).

DETERMINATION OF ANTIMONY IN THE PRESENCE OF BISMUTH*

S.S.M.A. KHORASANI

Department of Chemistry, University of Dacca

(Received July 2, 1964)

During a study of the electronic and magnetic properties of antimony-bismuth alloys, a method was required for rapid and accurate determination of antimony in the presence of bismuth. Conventional methods¹ usually require the antimony to be selectively separated first, while in some colorimetric methods, applicable only at trace concentrations, separation may not be necessary. In the rhodamine-B method² it is necessary that the bismuth concentration should be kept within the prescribed limits. The iodide method³ permits simultaneous determination of antimony and bismuth but the accuracy is low (± 2 percent). The methyl violet method⁴ is selective for antimony but not so accurate. During titrimetric determination of antimony, the difficult step of separation may be avoided and analysis quickly performed if the interfering elements are selectively masked. For example, Cu(II) can be masked with citrate⁵ during iodimetric titration of Sb(III).

*This work was carried out under a Research Project financed by the Pakistan Atomic Energy Commission.

It is known⁶ that Bi (III) forms a strong complex with EDTA which remains undercomposed even in acid solutions. The EDTA complex of Sb (III) is, however, very weak.⁷ It was further found that iodimetric titration of Sb (III) is not affected by the presence of EDTA. This suggested a method for selective masking of Bi (III) present, during titration of Sb (III) with iodine.

Method

Reagents.—Antimony potassium tartrate solution, 0.1 M; EDTA (di-sodium salt) solution, 0.1 M; iodine solution, 0.01 N; Rochelle salt solution, saturated; sodium bicarbonate solution, saturated; sulphuric acid, concentrated; starch indicator, 1 percent freshly prepared; antimony metal, powder; bismuth metal, granular; copper metal, foil; lead metal, foil.

All these reagents, except EDTA, antimony metal and bismuth metal, were Anala R grade B.D.H. chemicals. The EDTA and antimony metal were reagent grade B.D.H. products while the bismuth metal was A.R. grade of Mallinckrodt Chemical Works, U.S.A.

The EDTA solution was standardised against pure mercury, while other solutions were standardised in the conventional way. The antimony metal was found to be 97.81 percent pure.

Procedure

For Antimony Potassium Tartarate in the Presence of EDTA.—Definite amount (~ 1.0 ml.) of the 0.1 M tartar emetic solution was measured out by means of a semi-micro burette and Rochelle salt solution (2 ml.) was added, followed by varying proportions of 0.1 M EDTA. The mixture was diluted with distilled water (50 ml.), made alkaline with sodium bicarbonate and titrated with iodine in the presence of starch (2 ml.). In the presence of a large excess of EDTA the blue colour of the solution at the end point tended to fade. Over-titration could be avoided by adding iodine to a point when the blue tinge was stable for thirty seconds.

For Mixtures of Antimony (Added as Tartar Emetic) and Bismuth—EDTA.—Bismuth metal (0.01–0.10 g.) was taken in a pyrex conical flask and tartar emetic solution (5 ml.) added. Concentrated sulphuric acid (4–6 ml.) was then added and the mixture was heated, gently until the tartarate was carbonised, and then strongly until all the

bismuth had reacted and carbon was completely oxidised. The mixture was cooled to room temperature when sulphates of antimony and bismuth crystallised out. Rochelle salt solution (10 ml.) and distilled water (50 ml.) were added and the mixture was boiled for 5 minutes to remove sulphur dioxide completely. The solution was cooled again to room temperature. At this stage antimony was completely in solution but some bismuth sulphate remained undissolved. The EDTA solution (5 ml.) was added and the excess acid was neutralised with sodium bicarbonate and finally made alkaline; the bismuth sulphate was then completely dissolved. Starch (2 ml.) was added and titrated with 0.01 N iodine.

Final Method for Synthetic Mixtures of the Metals or Alloys.—Antimony (0.05 g.) and Bismuth (0.01 to 0.10 g.), or any convenient amount of the alloy containing the two metals in the above proportion was dissolved by heating with concentrated sulphuric acid (5–7 ml). It was cooled to room temperature and Rochelle salt solution (10 ml.) was added, followed by distilled water (50 ml.) The mixture was boiled for 5 minutes to remove sulphur dioxide completely. The rest of the procedure was the same as already described.

Results

Results given in Table 1 indicate that the presence of EDTA has practically no influence on the iodimetric titration of Sb(III) except at very high concentrations when some overtitration may occur. In Table 2, results for titration of Sb(III), derived from tartar emetic, in the presence of Bi(III)-EDTA under simulated conditions approaching that for metal mixtures or alloys, is given. It is found that Bi(III) when present in amounts 16 to 160 percent of Sb(III) does not influence the results for the latter which are accurate to ± 0.23 percent. Final results for analysis of synthetic mixtures of the metals or alloys are given in Table 3. It will be seen that for samples containing 0.05 g. Sb and 0.012 to 0.1147 g. Bi, Sb can be determined with an accuracy of ± 0.60 percent. With proper manipulation a sample can be easily analysed within 30 minutes.

Since estimation of Bi by EDTA is subject to interference by Sb⁶, no attempts were made to analyse the solution (after iodine titration) for Bi by back titration of excess EDTA. Separation of Bi by sulphide method should enable its determination.

It may be mentioned that the proposed method was also found suitable for determination of Sb

TABLE 1.—TITRATION OF ANTIMONY (III) WITH IODINE IN THE PRESENCE OF EDTA.

| Antimony taken g. | 0.1 M EDTA added ml. | Antimony found g. | Error % |
|-------------------|----------------------|-------------------|---------|
| 0.01243 | 0.0 | 0.01243 | 0.00 |
| 0.01243 | 5.0 | 0.01243 | 0.00 |
| 0.01243 | 10.0 | 0.01237 | -0.48 |
| 0.01243 | 15.0 | 0.01249 | +0.48 |
| 0.01243 | 20.0 | 0.01255 | +0.97 |

TABLE 2.—DETERMINATION OF ANTIMONY (III) IN THE PRESENCE OF BISMUTH (III)-EDTA.

| Antimony taken g. | Bismuth taken g. | Antimony found g. | Error % |
|-------------------|------------------|-------------------|---------|
| 0.06039 | 0.0102 | 0.06039 | 0.00 |
| 0.06039 | 0.0249 | 0.06037 | -0.12 |
| 0.06039 | 0.0511 | 0.06039 | 0.00 |
| 0.06039 | 0.0822 | 0.06053 | +0.23 |
| 0.06039 | 0.1020 | 0.06039 | 0.00 |

TABLE 3.—DETERMINATION OF ANTIMONY IN SYNTHETIC MIXTURES AND ALLOYS WITH BISMUTH.

| Antimony taken g. | Bismuth taken g. | Antimony found g. | Error % |
|-------------------|------------------|-------------------|---------|
| 0.0499 | 0.0120 | 0.0497 | -0.40 |
| 0.0500 | 0.0250 | 0.0503 | +0.60 |
| 0.0496 | 0.0525 | 0.0496 | 0.00 |
| 0.0510 | 0.0791 | 0.0512 | +0.39 |
| 0.0500 | 0.1147 | 0.0503 | +0.60 |

in presence of Cu or Pb. In the former case, analysis of mixtures containing 0.05 g. Sb and 0.01 to 0.10 g. Cu gave results accurate to ± 0.70 percent. When Pb is used in place of Cu, results are more accurate (± 0.50 percent), but in this case addition of even excess of EDTA fails to bring the PbSO_4 into complete solution. This however does not affect the titration.

Acknowledgement.—The author wishes to thank Professor M.H. Khundkar for his kind interest in the problem.

References

1. N.H. Furman, *Scott's Standard Methods of Chemical Analysis* (D. Van Nostrand Co. Inc., New York, 1939), fifth edition, Vol. II, pp. 1399, 1401.
2. G. Charlot and Denise Bezier, *Quantitative Inorganic Analysis* (Methuen and Co, Ltd., London, 1957), p. 332.
3. E.W. McChensey, *Ind. Eng. Chem. Anal. Ed.*, **18**, 146 (1946).
4. H. Goto and Y. Kakita, *Science Reports., Research Inst. Tohoku Univ. Ser. A*, **4**, 589 (1952).
5. M.R. Verma and Y.P. Singh, *J. Sci. Ind. Res., B, India*, **13** (10), 709 (1954).
6. G. Schwarzenbach, *Complexometric Titrations* (Methuen and Co. Ltd., London, 1960), p. 93.
7. S.S.M.A. Khorasani, *Pakistan J. Sci. Ind. Res.*, **6** (3), 208 (1963).

STUDIES ON THE TENSILE CHARACTERISTICS OF BIBRIK WOOL

A.A. WAKIL, FAIZULLAH KHAN, TAJ ALI WAZIR
AND MIAN TAJ YOUNIS

*North Regional Laboratories, Pakistan Council
of Scientific and Industrial Research, Peshawar*

(Received December 10, 1964)

Introduction

Study has been made on various samples of Bibrik wool fibres collected from different parts of Quetta, Baluchistan. The samples were tested, for diameter, elongation and strength; stress and tensile strength were determined. The tensile properties of true and medullated wool fibres have been compared with that of Kaghani, Hashtnagri, Harnai, Lohi and Waziri wool fibres in order to determine the values and suitability for apparel cloth or carpet manufacture.

Experimental

Each sample was cleaned, sorted into true and medullated types of fibres with the help of benzene test as given by Mumtaz Ahmad¹ in his work on Hashtnagri wool properties. The methods used for determination of breaking strength are the same as described in Harnai² wool fibres.

Results and Discussion

The mean values of all these properties are given in Table 1. Standard deviation and coefficient

of variation in diameter, breaking strength, stress and tensile strength are shown in Table 2. The relation between diameter and breaking strength of true and medullated wool fibres was studied and finally the graph has been plotted between them and a straight line is obtained in the case of medullated type of wool, while for true fibres the strength does not increase regularly with the increase of diameter, but at some points it also decreases with the increase of diameter.

The average type content in the 30 representative samples was 66.8 percent, true wool, 33.2 percent medullated. The variation in medullated fibres is from 3.2 percent to 37.2 while true fibres

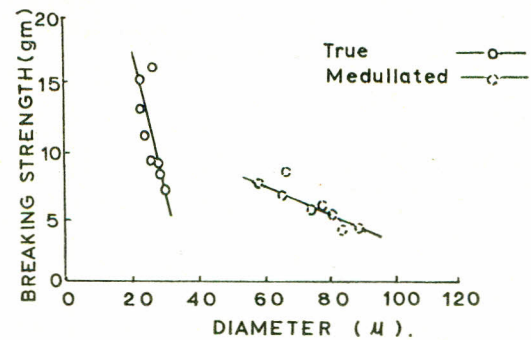


Fig. 1.—Relationship between breaking strength and diameter of true, medullated Bibrik wool fibres.

TABLE 1.—MEAN VALUES OF ALL THE TRUE, MEDULLATED WOOL FIBRES.

| Name of Type | Diameter (μ) | Breaking strength | | Elongation % | Stress mg./μ ² | Tenacity g. | Tensile strength kg./cm ² |
|---------------|--------------|-------------------|---------------|--------------|---------------------------|-------------|--------------------------------------|
| | | Single fibre g. | in Bundle kg. | | | | |
| True | 26.7 | 6.6 | 0.95 | 24.2 | 12.2 | 1.3 | 1534 |
| Heterotypical | — | — | — | — | — | — | — |
| Medullated | 72.3 | 25.4 | 1.18 | 31.8 | 5.7 | 0.6 | 675 |

TABLE 2.—STANDARD DEVIATION AND COEFFICIENT OF VARIATION OF DIAMETER, BREAKING STRENGTH, STRESS, TENSILE STRENGTH OF TRUE, HETEROTYPICAL AND MEDULLATED WOOL FIBRES.

| Type of fibres | Coefficient of Variation | | | Stress mg./μ ² | Standard Deviation | | | Stress mg. 1/μ ² |
|----------------|--------------------------|--------------------------------------|----------------------|---------------------------|--------------------|--------------------------------------|----------------------|-----------------------------|
| | Diameter μ | Tensile strength kg./cm ² | Breaking strength g. | | Diameter μ | Tensile strength kg./cm ² | Breaking strength g. | |
| Medullated | 3.0 | 30.3 | 10.2 | 24.5 | 2.2 | 205 | 2.6 | 1.4 |
| True | 13.1 | 29.1 | 33.3 | 2.1 | 3.6 | 447 | 2.2 | 0.36 |

TABLE 3.—MEAN VALUE OF FIBRE DIAMETER.

| Breed | True | | Heterotypical | | Medullated | |
|------------|------------|------------|---------------|------------|------------|------------|
| | Diameter μ | C. of V. % | Diameter μ | C. of V. % | Diameter μ | C. of V. % |
| Bibrik | 26.7 | 13.1 | — | — | 72.3 | 3.0 |
| Kaghani | 29.2 | 7.5 | 40.0 | 10.2 | 57.0 | 18.9 |
| Hashtnagri | 25.2 | 11.9 | 40.5 | 9.3 | 51.8 | 12.5 |
| Harnai | 28.7 | 11.7 | 45.1 | 9.1 | 75.2 | 15.3 |
| Lohi | 20.8 | 10.9 | 39.8 | 16.8 | 66.8 | 16.1 |
| Waziri | 24.4 | 14.3 | 47.4 | 6.5 | 58.8 | 12.7 |

C. of V. = Coefficient of Variation.

is from 35.8 to 75.5 percent. The percentage variation shows that fineness of this breed is greater, while its coarser property is lesser.

The diameter of the medullated fibres ranges from 58.2 μ to 88.8 μ (mean 72.3 μ) with the coefficient of variation and standard deviation 3 ± 2.2 (II) while for true fibres the diameter ranges from

22.6 μ to 37.8 μ (mean 26.7 μ) with the coefficient of variation and standard deviation (13.1 \pm 2.6) as shown in Table 2. The fine wool fibres having the diameter upto 20 μ to 30 μ can be used for medium to low quality cloth of 24^s to 62^s spinning quality. The strength generally increases with the increase of diameter in the case of true fibres while it shows decreasing result in the case of

TABLE 4.—MEAN VALUE OF FIBRE STRENGTH.

| Breed | True | | Heterotypical | | Medullated | |
|------------------|-------------------|----------|-------------------|----------|-------------------|----------|
| | Breaking strength | C. of V. | Breaking strength | C. of V. | Breaking strength | C. of V. |
| | g. | % | g. | % | g. | % |
| Kaghani | 16.4 | 9.1 | 21.6 | 9.4 | 29.9 | 7.7 |
| Hashtnagri | 8.3 | 20.5 | 20.2 | 19.3 | 31.3 | 7.7 |
| Harnai | 8.2 | 20.7 | 23.2 | 17.2 | 30.2 | 7.6 |
| Lohi | 7.4 | 34.3 | 10.6 | 37.2 | 19.0 | 24.3 |
| Waziri | 5.7 | 19.3 | 19.2 | 28.0 | 27.2 | 37.0 |
| Bibrik | 26.6 | 10.2 | — | — | 25.4 | 29.1 |

TABLE 5.—MEAN VALUE OF FIBRE ELONGATION.

| Breed | True | | Heterotypical | | Medullated | |
|------------------|------------|----------|---------------|----------|------------|----------|
| | Elongation | C. of V. | Elongation | C. of V. | Elongation | C. of V. |
| | % | % | % | % | % | % |
| Bibrik | 24.2 | 15.2 | — | — | 31.8 | 3.3 |
| Kaghani | 34.0 | 17.9 | 41.0 | 3.8 | 49.0 | 6.7 |
| Hashtnagri | 28.0 | 13.9 | 29.0 | 11.2 | 31.0 | 9.3 |
| Harnai | 31.0 | 14.8 | 26.0 | 31.1 | 28.1 | 19.2 |
| Lohi | 40.0 | 32.5 | 40.0 | 26.2 | 34.0 | 20.0 |
| Waziri | 35.1 | 42.1 | 39.05 | 9.2 | 39.5 | 42.6 |

TABLE 6.—PERCENTAGE COMPOSITION OF TRUE AND MEDULLATED, KAGHANI, HASHTNAGRI, HARNAI, LOHI AND WAZIRI WOOL FIBRES.

| Breed | Type of Fibres as Percentage of Total Fibres. | | |
|------------------|-----------------------------------------------|-----------------|--------------|
| | True % | Heterotypical % | Medullated % |
| Kaghani | 60 | 22 | 13 |
| Hashtnagri | 54 | 25 | 21 |
| Harnai | 55 | 27 | 18 |
| Lohi | 53 | 20 | 17 |
| Waziri | 33 | 49 | 17 |
| Bibrik | 66.8 | — | 33.2 |

medullated fibres. The coefficient of correlation found for true and medullated fibres, confirms the fact that this wool is fine and can be best suited for apparel cloth.

Comparing the tensile properties of Bibrik wool with other breeds i.e. Kaghani, Hashtnagri, Harnai, Lohi and Waziri, it was found that the values of diameter and elongation are the same, while the breaking strength differs widely (given in Table 4). It is concluded from the above comparison that the Bibrik wool is best suited in weaving woollen cloth. Furthermore, a soft wool having minimum elongation of 25 percent is desirable for weaving apparel cloth.

Acknowledgement.—The authors wish to express their gratitude to Dr. S.A. Warsi, Director, North Regional Laboratories, PCSIR., Peshawar, for his keen interest in the problem.

References

1. Mumtaz Ahmad, Pakistan J. Sci. Ind. Res., **6**, 8 (1963).
2. A.A.Wakil and Amir Mohammad, Science and Industry, **1**, 237 (1963).

PREPARATION AND BIOLOGICAL EVALUATION OF A PROTEIN ISOLATE FROM COMMERCIAL OIL-SEED CAKES

S. MAQSOOD ALI, IFTIKHAR ALI SHEIKH,
M. ARSHAD AND M. ASLAM

*West Regional Laboratories, Pakistan Council of
Scientific and Industrial Research, Lahore*

(Received August 15, 1964)

Introduction

In earlier papers, Ali,¹ and Ali and Miller² have shown that average Pakistani diet is deficient in proteins and this can be remedied by increasing the protein supply from other sources such as oil-seed cakes, fish flour, leaf protein, etc. The oil-seed which is abundantly available in Pakistan, is cotton-seed, and a good deal of cotton-seed cake is produced in the country and is mainly used as a cattle feed. Attempts were, therefore, made to prepare an edible cotton-seed flour from cotton-seed cake. This was successfully produced³ and its protein value could be increased to the level of animal proteins by proper supplementation.⁴ The present investigations have been carried out with a view to preparing a protein isolate from

commercial cotton-seed cake. Its net protein utilization (N.P.U.) value was also determined to evaluate protein quality, and compared with the N.P.U. value of the original material to ensure that there was no gross impairment of the protein quality by the processing technique.

Materials and Method

Cotton-seed cake (Lever Brothers, Raheemyar Khan) was ground to pass 100 mesh and defatted using petroleum ether (b.p. 60-90°C.); one kg. of the commercial cake yielded 560 g. of the defatted cake containing 40.6 percent protein.

The method for the isolation of protein is based on the technique adopted by K. Anantharaman *et al.*⁵ from groundnut meal for isolating groundnut protein isolate. This essentially consists of extracting the protein by alkaline solution and precipitating the protein by acidifying the alkaline extract. After making a number of trials by varying the pH of the alkaline solution (A) and the pH of the acidified solution (B) to get the maximum yield of protein (Table 1), the following method was adopted.

TABLE 1.—YIELD OF COTTON-SEED PROTEIN ISOLATE UNDER VARYING CONDITIONS FROM 100 g. OF THE CAKE.

| Product No. | pH of NaOH solution (A) | pH of acidified curd (B) | Yield of protein isolate, dry weight (g.) | % of protein in protein isolate |
|-------------|-------------------------|--------------------------|-------------------------------------------|---------------------------------|
| 1 | 8 | 3 | 9.5 | 74.1 |
| 2 | 8 | 4 | 10.0 | 74.2 |
| 3 | 8 | 5 | 9.9 | 70.0 |
| 4 | 8 | 6 | 8.0 | 70.1 |
| 5 | 9 | 3 | 15.5 | 75.0 |
| 6 | 9 | 4 | 16.0 | 75.0 |
| 7 | 9 | 5 | 15.0 | 70.2 |
| 8 | 9 | 6 | 11.2 | 70.3 |
| 9 | 10 | 3 | 24.0 | 75.1 |
| 10 | 10 | 4 | 25.0 | 76.0 |
| 11 | 10 | 5 | 20.0 | 75.15 |
| 12 | 10 | 6 | 15.5 | 75.2 |
| 13 | 11 | 4 | 25.0 | 70.0 |

To 100 g. of cotton-seed flour 800 ml. of 0.1N sodium hydroxide was added. The pH was approximately 10. The mixture was shaken occasionally and kept overnight. A few drops of chloroform were added to prevent fermentation. The mixture was then filtered through a cloth bag and the residue was treated twice with 0.1N sodium hydroxide and filtered. It was repeatedly washed with water and sun-dried to serve as a cattle feed.

The filtrates from the above process were combined and acidified with 2N sulphuric acid with repeated shaking. When all the protein was coagulated and settled down, the proteins were separated by centrifuging and repeatedly washed with water until pH 6.5 was reached. It was treated with alcohol to remove water and finally dried in a vacuum oven at 50°C.

Loss of Protein in Processing.—The protein isolate was found free of gossypol when tested according to the methods of Podol Skaia,⁶ and Royce, Harrison and Dean⁷ as modified by Nazir *et al.*³ In order to evaluate the recovery of protein from the original material, the fractions were weighed and nitrogen was estimated by micro-Kjeldahl method⁸ and converted to protein by multiplying with 6.25. The results are given in Table 2 which show that about 11 percent protein is lost in processing.

Determination of Net Protein Utilization.—The cotton-seed flour and the cotton-seed protein isolate were mixed in a semi-synthetic diet so that the protein content was 10 percent. The composition of the diets/kg. is shown in Table 3.

The N.P.U. at 10 percent protein level was determined according to the method of Miller and Bender,⁹ using male albino rats, weighing 35-40 g. for a period of ten days. The results are given below:

| | N.P.U. % | | |
|-----------------------------|----------|--------|------|
| | Exp. 1 | Exp. 2 | Mean |
| Cotton-seed flour | 41.6 | 44.4 | 43.0 |
| Cotton-seed protein isolate | 39.0 | 41.17 | 40.1 |

Discussion

Use of cotton-seed flour as source of protein in developing countries has been limited because (1) it contains gossypol which needs to be completely

TABLE 2.

| | Wt. of protein concentrate (g.) | Protein % | Total Protein (g.) |
|--------------------------------------------------|---------------------------------|-----------|--------------------|
| Cottonseed flour (A) | 100.0 | 40.6 | 40.6 |
| Protein isolate (B) | 25.0 | 76.0 | 19.0 |
| Residue left after extracting with 0.1N NaOH (C) | 61.0 | 17.5 | 10.5 |

Protein left in aqueous phase = A - (B + C) = 40.6 - (19.0 + 10.5) = 11.1 g. Loss of protein, 11.1%

TABLE 3.—COMPOSITION OF DIETS.

| Diet | Protein Isolate (g.) | Maize Starch (g.) | Fat. (Star Vanaspati) (g.) | Formula I to containing vitamins and minerals |
|-----------------------------|----------------------|-------------------|----------------------------|-----------------------------------------------|
| Non-protein | — | 500.0 | 150.0 | 350.0 |
| Cotton-seed flour | 250.0 | 250.0 | 150.0 | 350.0 |
| Cotton-seed protein isolate | 133.3 | 366.7 | 150.0 | 350.0 |

removed before it can be used as human food and (2) commercial cotton-seed cake may contain dust particles and other impurities due to unhygienic storage conditions.

These disadvantages have been largely overcome in the protein isolate described in this paper. Further it contains a higher concentration of protein (76 percent), is free from gossypol and other impurities and can therefore be considered suitable as a protein supplement in Pakistani dietary.

During the course of processing, only 11.1 percent protein is lost and the residue left after extracting protein can still be used as cattlefeed. The N.P.U. determination has shown that the protein value of the isolate was only slightly lower than that of the original material which shows that not much damage to protein has been caused during the course of processing.

Acknowledgement.—The authors are grateful to Dr. Karimullah, Director, West Regional Laboratories, for providing necessary facilities to work on this problem.

References

1. S.M. Ali, Proc. Nutr. Soc., **20**, 105 (1961).
2. S.M. Ali, and D.S. Miller, Pakistan J. Sci. Ind. Res., **6**, 290, (1963).
3. M. Nazir, M. Saeed and Karimullah, Pakistan J. Sci. Ind. Res., **6**, 79 (1963).
4. S.M. Ali, M. Jamil and A. Razzaq, Pakistan J. Sci., **16**, 113 (1964).
5. K. Ananthraman *et al.*, Food Sci., **11**, 1 (1962).
6. M.Z., Podol skaia, Oil and Soap, **23**, 132 (1946).
7. H.D. Royce, Harrison and D. Deans Ind. Eng. Chem., Anal. Ed., **12**, 741 (1940).
8. *Methods of Analysis*, Association of Official Chemists (George Banta Publishing Co., Menasha, Wisconsin, U.S.A., 1955), eighth edition, p. 805.

9. D.S. Miller and A.E. Bender, Brit. J. Nutr., **9**, 382 (1955).
 10. S.M., Ali, M. Hanif and A.S. Alvi, Pakistan J. Sci. Res., **15**, 153 (1963).






A NOVEL REARRANGEMENT REACTION

ASLAM BUTT AND I.A. AKHTAR

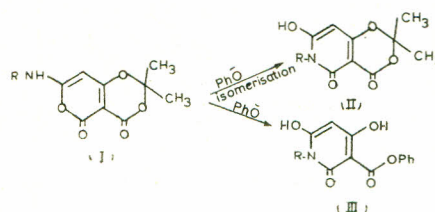
*Drugs and Pharamaceutical Research Division,
 Central Laboratories, Pakistan Council of Scientific
 and Industrial Research, Karachi*

(Received December 15, 1964)

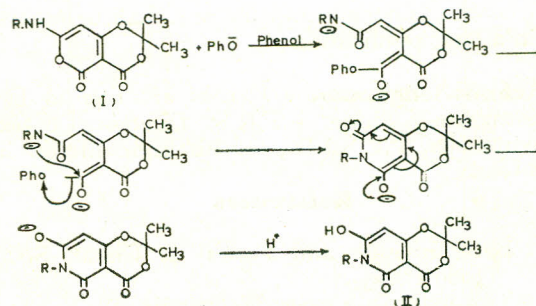
Formation of ethyl-1,2-dihydro-4,6-dihydroxy-1-phenyl-2-oxo-pyridine-3-carboxylate¹ (VI), from 7-anilino-2, 2-dimethyl-4,5-dioxopyrano (4,3-d)-1, 3-dioxin under the influence of sodium ethoxide has already been reported and generality² of the reaction has been confirmed. Treatment of the compounds represented by formula(I) with phenoxide in phenol did not give analogous products i.e. no trace of phenylester pyridones (III) were found; instead these rearranged to form new dicyclic products (II) listed in the following along with their ultra-violet light absorption data:

| Amino No. | pyrano-1,3-dioxins ⁴ (I) R | Product II | M.P. | U.V. light absorption (in ethanol 95%) | |
|-----------|-------------------------------------------------------------------------------------|---------------------------------------------------|------|----------------------------------------|------|
| | | | | max | log |
| 1. |  | C ₁₅ H ₁₃ NO ₅ | 214° | 316 | 4.69 |
| 2. |  | C ₁₆ H ₁₅ NO ₅ | 188° | 316 | 4.57 |
| 3. |  | C ₁₅ H ₁₂ ClNO ₅ | 184° | 312 | 4.63 |
| 4. |  | C ₁₅ H ₁₂ BrNO ₅ | 207° | 313 | 4.39 |
| 5. |  | C ₁₉ H ₁₆ NO ₅ | 194° | 313 | 4.49 |

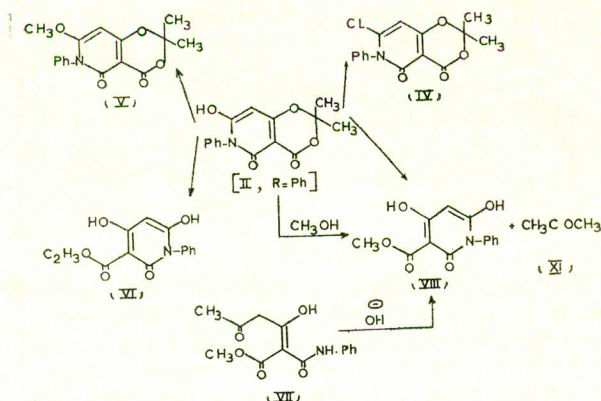
These new dicyclic compounds have a characteristic absorption in the range λ_{\max} 316-312 m μ and so these resemble chloropyrano-1,3-dioxins³ which have the characteristic absorption in the same region. These are phenolic in character and produce effervescence with aqueous sodium bicarbonate. These reactions of phenoxide on the compounds (I) can be written as follows:



These are formed most probably by the nucleophilic attack of phenoxide anion on the pyrane ring and then recyclisation took place forming a new C-N bond with the concomitant expulsion of the phenoxide anion. 1,3-dioxin ring remained unchanged. The proposed mechanism is as follows:



In agreement with the above structure (II) assigned to these new products, the compounds C₁₅H₁₃NO₅ (II, R=Ph) reacted with phosphorus oxychloride and yielded a chloro-product C₁₅H₁₂ClNO₄ (IV) m.p. 163° U.V. λ_{\max} 328m μ (log ϵ , 4.01), I.R. ν (in Nujol) 1751 cm⁻¹ (C=O,4) 1664 cm⁻¹ (C=O,5), evidently formed by the removal of hydroxyl group at position 7 by chlorine, and consequently it was neutral in character. Treatment of (II, R=Ph) with diazomethane, gave another neutral product C₁₆H₁₅NO₅ (V) m.p. 183°, U.V. λ_{\max} 300m μ (log ϵ , 4.03), λ_{\max} 276m μ (log ϵ , 4.30), I.R. ν 1724 cm⁻¹ (C=O,4), 1672 cm⁻¹ (C=O,5). Further reaction of (II, R=Ph) with sodium ethoxide in ethanol and sodium methoxide in methanol yielded ethylester pyridone (VI) and methylester pyridone (VIII), respectively and were identified by authentic samples prepared by standard method.¹ The structure (II) for the new products was confirmed when the compound (II, R=Ph) reacted with methanol alone, forming methylester pyridone (VIII) and acetone (XI) which was identified as its 2,4:dinitrophenylhydrazone. The above degradative reactions are depicted as follows:



The conversion of (I) into (II) represents new heterocyclic rearrangement and is general in nature. This work has been completed and shall be reported in a later publication.

Acknowledgement.—Thanks are due to Dr. Salimuzzaman Siddiqui, F.R.S., Director, Central Laboratories, P.C.S.I.R., for his keen interest in this work.

References

1. Butt, Elvidge and Foster, *J. Chem. Soc.*, 3069 (1963).
2. This work is in press (*Tetrahydon*).
3. S.J. Davis and J.A. Elvidge, *J. Chem. Soc.*, 2251 (1953).
4. Prepared by the method of S.J. Davis and J.A. Elvidge, *J. Chem. Soc.*, 4109 (1962).

A NOTE ON THE NATURE OF BONDING IN LEATHER

M. ARSHAD A. BEG

Central Laboratories, Pakistan Council of Scientific and Industrial Research, Karachi

(Received March 5, 1965)

An extensive amount of work has been done to elucidate the nature of bonding in leather. The main theories in this connection are the Adsorption theory, the Residual valence theory, the Salt formation theory and the Coordination theory. Among these the Coordination theory is placed on a better footing and explains the mechanism of tannage reasonably well.¹ This communication is concerned with the explanation of the mechanism of tannage in terms of coordination polymer formation.

Coordination polymers have been worked out only recently² and are substances in which a metal atom is linked with poly-functional ligands. Polymers so far known are substances which have carbon, hydrogen, nitrogen and oxygen as the building units. Coordination polymers on the other hand are compounds which have an inorganic backbone, or substances in which an inorganic element is imbedded in an organic casing or a shell. Collagen presents just this type of picture and it is possible to explain the various properties of leather, and thus place the coordination theory on a much stronger footing.

Collagen is a polyfunctional organic ligand

having crosslinks such as $\begin{array}{c} | \\ \text{C}=\text{O}-\text{HN}^+ \\ | \end{array}$ as in the

coordinate valence bond, which are mainly hydrogen bonds. It has in addition salt like linkages between the basic and the acidic groups of the adjacent polypeptide chains which impart zwitterionic properties to the collagen. As early as 1929 it was suggested by Meyer that the role of the tanning agent is to introduce crosslinking in the protein lattice. The most suitable tanning agents are also those which are themselves poly-functional in nature. Thus polyphenols or tannins are able to introduce crosslinks among the polypeptide chains and so are the mineral tanning agents which are metal ions having empty d-orbitals, or formaldehyde which has a polymeric structure itself. The formation of crosslinks through the tanning agents allows the collagen portion of the molecule to approach greater stability than would otherwise be the case. That this stability is attained through the tanning process is indicated by the rise in the shrinkage temperature. In the case of coordination polymers also the introduction of crosslinks by metal ions gives additional stability to the organic portion of the molecule.

Crosslinking through coordination brings about order in the molecular lattice, and affords stability to the collagen through hydrogen bonding. Since hydrogen is being shared by the polypeptide chains it accounts for a high molecular weight of 55,000 for the native collagen, and treatment with formaldehyde results in the formation of subunits with a molecular weight of 11,000,³ apparently due to the formation of a crosslink which inhibits chain growth as is the case with coordination polymers.⁴

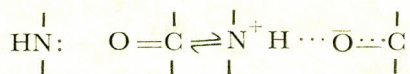
Tannage possibly involves two steps: (1) The acidic condition in which tannage occurs makes the carboxyl group available for coordination, and

(2) the zwitterionic nature of the pelt releases a charge on the amino groups. The former provides coordination sites and the latter along with the hydroxyl and other proton donor groups acts as the catenating group providing a strong backbone. Catenation through hydrogen may be taken as hydrogen bond formation. The role of catenating groups is just as important as that of the coordinating groups for the formation of coordination polymers, since their absence reduces the uptake of chromium as in acetylation of the amino and hydroxyl groups.

The various mineral tanning agents are fixed in different ways but on the whole involve the same mechanism viz. introduction of crosslinks. The fixation of polymetaphosphate and silica seems to be similar. Fixation of silica is only possible when it exists in sol form i.e. in a polymeric condition, prior to tanning. A polymer is able to present itself in the form of a polyfunctional group which may then introduce crosslinks in various ways.

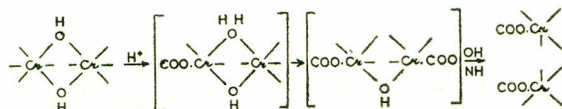
In the case of chrome tannage only 1 percent of Cr_2O_3 is sufficient to bring about crosslinks for the stability of the collagen. The rest of the chrome compound is utilized in the formation of further subunits, possibly having lower molecular weights. The mechanism may be represented in the following form.

The collagen lattice should be considered as a system of π electrons arising out of the $\text{C}=\text{O}$ linkages in the peptide chain. The lone pair on nitrogen and oxygen cause high repulsions and since the bond pair: bond pair repulsion is much lower than a lone pair: lone pair repulsion,⁵ the stereochemical distribution for least electrostatic repulsion will cause a puckering of the peptide chain. It is the stereochemical distribution of this type that makes the various functional groups of the collagen available for reaction. The hydrogen in the peptide chains will interact with the π electrons of the carbonyl or keto-imide linkages and produce hydrogen bonds. Mobile π electrons usually give rise to unusual stability and their interaction with lone pair electrons results in the establishment of a charge on the atoms concerned e.g. the interaction of the lone pair on nitrogen will result in the following type of structures:



A hydrogen bond is therefore easily formed. NHO bridges as indicated here are quite common in proteins. Hydrogen bonds are also formed by other groups such as hydroxy, amide, amino

and carboxy. The reaction may be started by the coordination of the carboxyl groups. Since every sixth residue in collagen has a carboxyl group, the uptake of chromium to stabilise this group is small. Under the acidic conditions of the pelt only this group can take part in the formation of a coordinate bond. The proton involved in the hydrogen bond is transferred to the OI-bridge and severs the chrome-OI bridge giving an open chain structure. Another chromium atom is then ready to be coordinated. The protons play a vital role and are responsible for carrying out the reaction to completion.



Since water exists in the lattice of collagen in an ice-like structure⁶ and in helical form the water liberated may be acting as a carrier, and thus the aquated complex may be getting distributed throughout the lattice of the protein.

References

1. S.G. Shuttleworth, *Chemistry and Technology of Leather* (Reinhold Publishing Corp., New York 1958), Vol. II, p. 281.
2. C.N. Kenney, *Chem. Ind.*, 880 (1960).
3. K.H. Gustavson, *The Chemistry and Reactivity of Collagen* (Academic Press Inc., New York, 1956), p. 236.
4. D.N. Chakravarty and W.C. Drinkard, *J. Ind. Chem. Soc.*, **37**, 517 (1960).
5. R.J. Gillespie and R.S. Nyholm, *Quart. Rev.*, **11**, 339 (1957).
6. H.J.C. Brendsen, *J. Chem. Phys.*, **36**, 3297 (1962).

SCOPE FOR GROWING AUTUMN POTATOES UNDER ORDINARY CONDITIONS IN THE PESHAWAR VALLEY

MUHAMMAD IBRAHIM BAJWA

Agricultural College, Peshawar University

(Received November 30, 1964)

Introduction

Potato is a heavy feeder (i.e. more plant food is needed) crop and requires a high state of soil fertility and plenty of water. Therefore, the main source of impediment in the way of its progress is the non-availability of organic manures and regular water supply in rural areas. Besides

this, it is thought that early frost in Peshawar Valley hinders the cultivation of the autumn crop of potatoes. In order to clear up these two points, the author has planned to carry out research, to see whether these objections have any scientific support.

For this, two dozes of organic manures in combination with two dozes of artificial fertilizers were tried. The behaviour of these treatments on the success of crop is discussed in this paper.

As the problem in view is of a special nature, not much information is available in the literature. Most of the work has been done under favourable conditions and it has been estimated that artificial fertilizers, whether alone or in combination with organic manure enhanced the yield of potatoes. Few references are made here.

Bushnell¹ found that the yields of potatoes are low sometimes due to the unsuitable physical condition of the field for crops. Fertilizers, both stable and artificial, can raise the yield by improving the physical condition and increasing the plant food material of the soil.

Daines and Mortain² found that the nitrogen supplied from a combination of organic and inorganic (ammonium sulphate) produced higher yields of potatoes. Nicholes and Catlow³ concluded that the nitrogen deficiency was the main factor limiting the total yield in potatoes. Low yields are also associated with the bulky use of organic manures. Larson⁴ has shown in his experiments that the generous supply of dung increases the yield of potatoes considerably, but has no influence on the effect of nitrogen or phosphorus. Zobel, Lorenz and Underhill⁵ concluded from their experiments, where they used two dozes (that is, 80 lbs. and 160 lbs. of nitrogen on potatoes) that both the dozes gave significantly higher yield than control.

Materials and Method

The experiment was laid out at the Agricultural Expansion Farm, Agricultural College, University of Peshawar, during 1961-62 and 1962-63, in a split plot design system, with 1/160th of an acre as net size of plot in six replications. The following treatments were tried, which were arranged at random, as shown by the sketch plan in Tables 1 and 2.

TABLE 1.—SKETCH PLAN SHOWING THE LAYOUT OF THE EXPERIMENT FOR THE YEAR 1961-62.

| | | | | | | | | | | | | |
|----------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|----------------|
| R ₁ | N ₁ 1 | M ₁ 2 | N ₂ 3 | N ₁ 4 | M ₂ 1 | N ₂ 2 | N ₂ 3 | M ₁ 4 | N ₁ 1 | M ₁ 2 | N ₂ 3 | R ₂ |
| R ₃ | N ₂ 1 | M ₂ 2 | N ₁ 3 | N ₁ 4 | M ₁ 1 | N ₂ 2 | N ₂ 3 | M ₂ 4 | N ₁ 1 | M ₁ 2 | N ₂ 3 | R ₄ |
| R ₅ | N ₁ 1 | M ₁ 2 | N ₂ 3 | N ₂ 4 | M ₂ 1 | N ₁ 2 | N ₁ 3 | M ₁ 4 | N ₂ 1 | M ₁ 2 | N ₁ 3 | R ₆ |

TABLE 2.—SKETCH PLAN SHOWING THE LAYOUT OF THE EXPERIMENT DURING 1962-63.

| | | | | | | | | | | | | |
|----------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|----------------|
| R ₁ | N ₂ 1 | M ₁ 2 | N ₁ 3 | N ₁ 4 | M ₂ 1 | N ₂ 2 | N ₁ 3 | M ₁ 4 | N ₂ 1 | M ₂ 2 | N ₁ 3 | R ₂ |
| R ₃ | N ₁ 1 | M ₂ 2 | N ₂ 3 | N ₁ 4 | M ₁ 1 | N ₂ 2 | N ₂ 3 | M ₂ 4 | N ₁ 1 | M ₁ 2 | N ₂ 3 | R ₄ |
| R ₅ | N ₂ 1 | M ₁ 2 | N ₁ 3 | N ₂ 4 | M ₂ 1 | N ₁ 2 | N ₁ 3 | M ₁ 4 | N ₂ 1 | M ₂ 2 | N ₁ 3 | R ₆ |

Treatments.—(a) Organic manure (Farmyard Manure) (i) M_1 =No manure. (ii) M_2 =12 cart-loads of farmyard manure per acre.

(b) Artificial fertilizer (ammonium sulphate). (i) N_1 =100 lbs. N in the form of ammonium sulphate per acre. (ii) N_2 =150 lbs. N in the form of ammonium sulphate per acre.

No basal doze of organic manure was applied to any plot. Farmyard manure, according to treatments, was applied about one month before sowing the crop and thoroughly mixed in the plots. Ammonium sulphate was applied before the earthing up of the crop. Only one weeding and one earthing up could be applied due to unavoidable circumstances. In all, five waterings were applied at the intervals of 12 to 15 days.

Due to the late arrival of the seed, the crop could not be sown in the first week of September during both years, according to our schedule. It was sown on 29th and 21st September, during 1961-62 and 1962-63, respectively. The crop was not attacked by any disease or insects during

both the periods but was badly affected by frost (which started from the third week of November and continued for more than 2 months at a stretch during 1962-63 only).

Ultimash variety was selected for the experiment because it is the latest high-yielding variety with best cooking qualities. The seed was applied by the Agriculture Department, West Pakistan, Lahore, from Sialkot and Lyallpur respectively.

Experimental

The results, thus obtained were statistically analysed and are put forth in Table 3. The data of actual yield per plot and per acre are given in Table 4.

Table 3 supplies the following results: (1) The dozes of organic manures were non-significant during 1961-62. But during 1962-63, M_1 (that is, no manure) gave a significantly higher yield at 1% level as compared to M_2 , that is, 12 cart loads of farmyard manure per acre. (2) The dozes of artificial fertilizers were statistically at par with each other during both the years. (3) Interactions.

TABLE 3.—ANALYSIS OF THE VARIANCE OF TUBER YIELDS (MAUNDS PER ACRE) OBTAINED FROM THE FACTORIAL EXPERIMENT ARRANGED TO STUDY THE EFFECT OF ORGANIC AND INORGANIC MANURES ON THE YIELD OF POTATOES (TUBERS) DURING 1961-62 AND 1962-63.

| Due to | 1961-62 | | | | | 1962-63 | | | |
|-------------------------------------|---------|---------|--------|---|---------|------------------------------|----------|------|---------|
| | D.F. | S.S. | M.S. | F | Remarks | S.S. | M.S. | F. | Remarks |
| Blocks | 5 | 574.58 | 114.91 | — | — | 13481.48 | 2696.29 | — | — |
| Manure (Organic) .. | 1 | 158.62 | 158.62 | — | — | 3026.26 | 3026.26 | 68.3 | 00 |
| Error I | 5 | 1794.98 | 358.99 | — | — | 221.51 | 44.30 | — | — |
| Nitrogen (Artificial fertilizer) .. | 1 | 10.40 | 10.40 | — | — | 164.01 | 164.01 | 0.74 | N.S. |
| Manure x Nitrogen .. | 1 | 43.53 | 43.53 | — | — | 175.94 | 175.94 | 0.79 | N.S. |
| Error II | 10 | 789.37 | 78.93 | — | — | 2205.47 | 2205.47 | — | — |
| Total: | | 3371.48 | 765.38 | | | 19274.67 | 18312.27 | | |
| | | | | | | C.D. at 1% level | | | |
| | | | | | | Manures = 2.71 mds. per acre | | | |
| | | | | | | Nitrogen = 4.28 " " " | | | |
| | | | | | | Manure | | | |
| | | | | | | Nitrogen = 6.06 " " " | | | |

TABLE 4.—ACTUAL YIELD OF POTATOES (TUBERS) PER PLOT IN SEERS AND CHATTANKS PER ACRE IN MAUNDS AND SEERS.

| Repl- cation | Yield per plot in seers and chattank | | | | | | Yield per acre in maunds and seers | | | | | |
|-----------------|--------------------------------------|--------|-------|---------|-------|--------|------------------------------------|-------|---------|---------|---------|---------|
| | 1961-62 | | | 1962-63 | | | 1961-62 | | | 1962-63 | | |
| | M1-N | M1-N2 | M2-N1 | M2-N2 | M1-N1 | M1-N2 | M2-N1 | M2-N2 | M1-N1 | M1-N2 | M2-N1 | M2-N2 |
| R1 | 26-4 | 37-7 | 49-14 | 40-6 | 22-12 | 26-2½ | 15-15 | 22-1½ | 105-0 | 149-30 | 199-20 | 161-20 |
| R2 | 30-3 | 25-4 | 38-12 | 37-12 | 8-9½ | 6-3 | 8-12 | 12-½ | 120-30 | 101-0 | 155-0 | 151-8 |
| R3 | 39-6 | 26-9 | 53-13 | 42-0 | 17-1 | 13-5 | 28-15 | 17-3½ | 157-20 | 106-10 | 215-10 | 168-0 |
| R4 | 47-15 | 54-2 | 38-6 | 21-1 | 11-8 | 13-15 | 8-7 | 4-1 | 191-30 | 216-20 | 153-20 | 84-10 |
| R5 | 39-6 | 31-8 | 69-9 | 57-2 | 19-3 | 22-9½ | 27-7½ | 27-2 | 157-20 | 126-0 | 278-10 | 228-20 |
| R6 | 26-4 | 35-7 | 34-2 | 56-9 | 14-7½ | 6-15½ | 16-9 | 13-15 | 105-0 | 141-30 | 136-20 | 226-10 |
| Means | 34-14½ | 34-11½ | 47-6½ | 42-9½ | 15-12 | 14-13½ | 17-3½ | 16-1½ | 139-23½ | 140-8½ | 189-26½ | 169-36½ |

(M×N) were also non-significant statistically during both the years.

Discussions and Conclusion

The experiment was arranged with the view to assess, whether the autumn potatoes can be raised in the Peshawar valley under the prevalent conditions in rural areas, where the availability of organic manure and water supply is a problem, and to confirm whether the artificial fertilizer can be a substitute for organic manures or not or if the yield of the crop is hindered in any way by early frost. As the study was of a peculiar nature, interesting and encouraging results have been obtained.

1. In heavy soils, with the normal interval of irrigation (12 to 15 days) without organic manures, supplemented with 100 pounds of nitrogen (5 to 6 maunds) per acre in the form of ammonium sulphate, normal yield of autumn potatoes can be produced, which is quite clear from Table 4.

2. If the frost starts from 15th to 20th November and continues for long, it does hinder the normal growth and the yield of autumn potatoes, provided the crop is sown after 20th September, which can be seen from Table 4. In the author's opinion, if the sowing is completed within the first week of September, this problem can be solved, but it requires further investigations.

The heavy frosts of November and December, 1962, would probably severely damage even early planted potatoes, but as stated above, the matter requires further study for confirmation.

References

1. Bushnell, *Sensitivity of Potato Plant to Soil Aeration*, J. Am. Soc. of Agronomy, **27**, (1938).
2. R.H. Dains, and W.H. Martin, *Hints to Potato Growers*, Nat. J., **20**, 1 (1940).
4. C. Larson, *Horticultural Abstracts*, **21**, 1951 (1950).
3. D.J. Nicholos and E. Catlow, *Annual Reports of Agriculture and Hort. Research Station*, (Long Ashton, Bristol, 1947,) p. 125-26.,
5. M.P. Zobel, O.A. Lorens, *Potato Fertilizer Trial* (Truck Crops. Mimco No. 54, 1952) p. 2.