Commission of the European Communities

INFORMATION ON AGRICULTURE

Evaluation of the hygienic problems related to the chilling of poultry carcasses

No. 22

October 1976

EVALUATION OF THE HYGIENIC PROBLEMS RELATED TO THE CHILLING OF POULTRY CARCASSES

Series : "Information on Agriculture" No. 22

This report contains an analysis of a number of experiments which have been carried out in some poultry slaughterplants. Such experiments have been implemented in Denmark, the Netherlands, the United Kingdom, France and Italy, with the aim of making an assessment from the hygienic point of view of different chilling systems presently employed in poultry slaughtering i.e. immersion-chilling system compared to some other chilling systems.

The results of the present study have in the view of the authors, demonstrated that no objection can be made as to the use of immersion chilling from the hygienic point of view provided these chilling systems are operated properly.

This study is only published in english.

Commission of the European Communities

INFORMATION ON AGRICULTURE

Evaluation of the hygienic problems related to the chilling of poultry carcasses

No. 22

October 1976

Manuscript finished in June 1976

COMMISSION OF THE EUROPEAN COMMUNITIES
DIRECTORATE-GENERAL FOR AGRICULTURE
Directorate: Agricultural Economics – Division: "Balance-sheets, Studies, Statistical Information"

P R E F A C E

The present study concerning the evaluation of the hygienic problems related to the chilling of poultry carcasses was prepared in the framework of the study-programme of the Directorate-General for Agriculture - Commission of the European Communities - by a group of scientists. The group was composed as follows :

Slagteri- of Konserveslaboratoriet DK- KØBENHAVN F	Messrs.	M. JUL B. SIMONSEN
Danish Research Institute for Poultry Processing DK - HILLERØD	Mr.	B. ANDERSEN
Station Expérimentale d'Aviculture F - PLOUFRAGAN	Mrs.	C. LAHELLEC
Università degli Study I - MILANO	Mrs.	C. MARENZI
Instituut voor Pluimveeonderzoek NL - BEEKBERGEN	Messrs.	B. ERDTSIECK R. MULDER C. VEERKAMP
Agricultural Research Council Food Research Institute GB - NORWICH	Messrs.	G. MEAD J. JONES

Coordinator

Laboratorium voor Hygiëne en Technologie van Eetwaren van Dierlijke Oorsprong Faculteit Diergeneeskunde Rijksuniversiteit B - GENT	Mr.	J. VAN HOOF

Observers

Bundesanstalt für Fleish Forschung D - KULMBACH	Mr.	L. LEISTNER
Institut für Veterinärmedizin des Bundesgesundheitsamtes D - BERLIN	Mr.	E. WEISE

The experiments were carried out between October 28th and December 18th, 1975 The present report, prepared by the coordinator, was submitted to the group of scientists.
For the statistical evaluation of the results, the coordinator was assisted by Apr. J. DEMEESTER (Laboratorium voor Algemene Biochemie en biologische Physicochemie, Faculteit der Farmaceutische Wetenschappen, Rijksuniversiteit Gent).

The Divisions "Balance-sheets, Studies, Statistical Information" and "Harmonization of laws, regulations and administrative provisions relating to veterinary matters and zootechnics" of the Directorate-General for Agriculture have participated in this project.

*

* *

Original : English

SUMMARY

I - INTRODUCTION

1. The directive of the EEC-Commission, issued June 19th, 1975, modifying the first paragraph of article 14 of the Directive 71/118 EEC on the hygienic distribution of fresh poultry meat, prohibits with effect from January 1st, 1978 the so-called "spinchiller" poultry chilling process currently in use.
This prohibition was mainly based on the consideration that, from the point of view of hygiene the chilling process would not give satisfactory results. Furthermore, it results in absorption of extraneous water into the carcasses which was thought to be hygienically undesirable.

2. The present study has been undertaken in order to permit the Commission in accordance with paragraph 2 of the article mentioned above, to submit to the Council a report on the chilling processes other than those prohibited in article 1.
Owing to the divergent data from previous studies relative to poultry chilling procedures, the Commission invited all Member States to designate expert scientists to cooperate in this common study. Scientists from Belgium, Denmark, France, the Federal Republic of Germany, Italy, the Netherlands and the United Kingdom took part in this project (1).
German scientists did not take part in the execution of the experimental work, but they assisted in the elaboration of the protocol and the discussion of the results obtained.

3. Since the so-called "spinchiller" poultry chilling process currently in use only represents one specific type of the existing alternative chilling procedures, and taken recent technological changes in the original system of immersion chilling which have modified several fundamental aspects of this chilling technique, other immersion techniques were included.
Therefore the aims of the present study were defined as follows :

- to analyse the comparative value, from the hygienic point of view, of different immersion-chilling systems presently employed, and
- to establish the comparison between the results obtained with the immersion-chilling system and other chilling systems.

This study could not include the "spray-chilling" or the combined "Spray-air-chilling" procedures, which had been studied experimentally since they

(1) see list of Institutes in the preface (p. I and II) of this report.

have not been developed into industrial practice. The selection of the abattoirs where the experiments were carried out was usually based on the relative importance of the slaughter- and chilling procedures applied in the plants in the participating Member States, except that in Denmark, very few plants use other than immersion chilling. The air-chilling plant selected in that country was selected because it was the only one available for experimental work.

It has to be underlined that, in order to get relevant information on these items the abattoirs studied in this experiment were requested to operate under normally practised conditions on the understanding that no desinfection was carried out between the different stages of the experiments at the day of operating.

Comparison of the obtained results, with those obtained from other poultry laboratory experiments, should therefore duly take into consideration this basic difference.

For comparison, the operation of the abattoris, the standard of disinfection of the equipment before start of operation and both quantitative (viable counts) and qualitative (salmonella-stracings) hygienic condition of carcasses at different stages in the slaughter procedure were also characterised. Attention was also paid to the rate of chilling, the uptake of extraneous water or the loss of weight under varying practical chilling conditions.

Finally, it should be stressed that the chilling operation represents only one out of a series of factors during raising, handling and processing of poultry, which have an impact on physical and microbiological standards of the final product.

Therefore, the results of a study on chilling procedures with regard to the standard of the product, can only be evaluated in relation to the conditioning of the birds after chilling, i.e. whether the birds are being sold in a fresh or in a frozen state.

II - MATERIALS AND METHODS

A- Technical data on equipment and processing techniques

A survey of all technical data is given in annex, tables 1 and 2 (cf. pages 1 to 8). A summary of the main characteristics is also presented on page 4 of the report.

a) Live birds

The study was entirely carried out on broilers belonging, however, to different breeds and weight classes. Specifications concerning live birds and their handling before slaughter are in tables 1 and 2, cf. annex p. 1 and 5 for birds slaughtered in the plants practising immersion or/and air chilling respectively.

b) Number of plants and type of slaughter- and chilling procedures

Experiments were made in 10 different plants.

- Immersion chilling was practised in plants 1, 2, 4, 5 and 5*.
- Air chilling was practised in plants 1A, 2A, 3A, 3*A, 4A and 5A.

In merely one plant comparative studies of both chilling procedures could be carried out (plant 5, 5A).
In all other cases, immersion- and air-chilled birds were examined in separate plants.

Amongst the 5 participating Institutes, 4 out of them included at least one of the mentioned chilling systems in their experiments. One Institute investigated air-chilling procedures exclusively (plants 3A and 3*A).

c) Slaughter procedures

In the plants practising an immersion-chilling procedure, the capacity of the slaughter lines ranged from 2,500 (plant 5*) to 9,500 (plant 2) birds/hr. The high capacity in the latter plant was achieved by the use of one slaughter- and two eviscerating lines.

In the air-chilling plants, the capacity was 2,040 (plant 1) to 7,000 (plant 4A) birds/hr. Plant 4 also disposed of eviscerating lines.

After passing through a water-contact stunner, birds were killed automatically, except for plants 1, 3*A, 5, 5A, where killing was performed manually. Bleeding times ranged from 91 to 200 sec. for the immersion- chilled and the air-chilled birds respectively.

	PLANT	1	2	4	5	5*
IMMERSION CHILLING	Slaughter capacity/hr	4,080	9,500	3,000 - 3,200	2,880	2,500
	Scalding type	high	high	high	low	low
	Plucking units	2	3	1	4	2
	Spray-cleaning	yes	yes	yes	yes	yes
	Evisceration	mechanically	mechanically	mechanically	manually	mechanically
	Spray-washing	yes	yes	yes	yes	yes
	Chilling: type	counter-current	± counter-current	counter-current	through-flow	"drag" chiller (± through-flow)
	units	2	1	1	2	1
	water temp. (°C)	1st / 2nd en. 19 / 12 ex. 11 / 5	en. 23.7 ±8.2 mid. 13.2 ±2.8 ex. 8.4 ±0.7	en. 12.6 ±0.9 mid. 7.7 ±0.3 ex. 5.1 ±0.4	1st / 2nd en. 11.9±0.5 / 0.3±0.2 mid. 11.9±0.5 / 0.4±0.2 ex. 12.2±0.6 / 0.4±0.2	en. 5.6 ±1.0 mid. 0.4 ±0.1 ex. 3.5 ±1.3
	water flow (l/carcass)	1st 1.5 / 2nd 1.0	0.28 (*) (cf. note p.7)	1.76 - 1.91	1st 4.89 / 2nd 1.24	3.12
	ice (kg/carc)	no	no	no	1.9	0.4
	Weighing	semi-automatical	automatical	automatical	manual	manual

	PLANT	1A	2A	3A	3*A	4A	5A
AIR CHILLING	Slaughter capacity/hr	2,040	3,100	5,400	2,875	7,000	2,880
	Scalding type	low	low	low	low	low	low
	Plucking units	3	3	2	2	4	4
	Spray-cleaning	no	no	yes	no	no	no
	Evisceration	manually	mechanically	mechanically	mechanically	mechanically	manually
	Spray-washing	yes	yes	yes	yes	yes	yes
	Chilling (air)	± tunnel	chilling room	tunnel	tunnel	tunnel	tunnel
	Weighing	manually	manually	manually	semi-automatic.	automatically	manually

TABLE 1 : Summary of main technical data on processing techniques for air- and immersion-chilling plants.

d) Scalding procedures

-Immersion-chilled birds

In plants 1, 2 and 4 the birds were high-scalded at average temperatures ranging from 59.0° to 62.4°C (measured at the exit-side of the scalding tank). In plants 5 and 5* birds were low-scalded at temperatures of approximately 50.5° and 52.6°C respectively.
With exception of plant 4, the scalding tanks were so constructed that both the entry and the exit were located at the same side of the tanks.

Water flows amounted from 0.22 to 0.36 l/carcass.

Residence times ranged from 62 to 202 sec. in dependence of the watertemperature and the capacity of the tanks (cf. annex table 1).

-Air-chilled birds

All birds were low-scalded for 90 sec. to a maximum of 202 sec. at average watertemperatures ranging from 50.5° to 52.2°C.

Water flows were almost equivalent to those used for the immersion-chilled birds (cf. annex table 2).
In plant 3*A only, the birds entered and left the scalding water at the opposite sides of the tank.

e) Plucking

Specifications on the type and number of pluckers and residence times of birds in immersion- and air-chilling plants are given in annex, p. 2 and 6 respectively.

Besides different plucking times, plucking procedures were characterized by considerable differences in the temperature of the water used. Data on total water flows were only available for plants 1 (0.76 l/carcass) and 1A (1.30 l/carcass).

Singeing of birds after defeathering was applied in plants 3A and 3*A only.

In plants 1, 2, 4 and 3A birds were spray-cleaned immediately after plucking. Specifications are given on p. 2 and 6 of the annex.

f) Evisceration procedures

Whereas in plant 5* only, the evisceration line included a full automatic 3 stage evisceration system comprising neck breaker, vent cutter, vent opener and eviscerator, all stages in evisceration were carried out manually in plants 1A and 5, 5A. In these plants, neck skin cuts and removal of the neck were also made by hand only.

In all other plants the procedure was highly mechanized, some operations however, such as the cutting and opening of the vent, required manual handling of the carcasses.

In plant 5 only, carcasses were supported both by the legs and by the wings in such a way that intestinal contents could not contaminate the lower parts of the carcass including the neck skin flap.

For several plants only fragmentary or no data were available concerning the amount of water available for cleaning of carcasses during evisceration. Whereas in plants 5, 5A and 5* no spray-washing was used until evisceration had been completed, it was stated that for plant 3*A no water was available at all during evisceration (cf. annex p. 3 and 7).

In one plant (e.g. plant 4A), the lower part of the neck skin was partly cut off from the carcass at the end of the evisceration line.

Veterinary inspection, comprising palpation and, if necessary, incision of each separate carcass was performed in plants 1, 1A, 4 and 4A only.

g) Spray-washing before chilling

Spray-washing of carcasses after evisceration was generally used. Detailed technical information is summarized on p. 3 and 7 of the annex. Except for some plants, e.g. 4 and 4A, these specifications indicate little or no similarity in the way of operation of the spray-washing systems used in the different plants.
In plants 2A and 5,5A spraying was completed by the action of rotating rubber flails on the surface of the carcasses passing through the spray-washer. Moreover, during the first week of the experiments the water used in plant 2A contained low concentrations of lactic acid (< 5 ppm). In the latter plant, immediately after spray-washing, carcasses passed through a hot air tunnel (60°C) in order to render a dry surface before chilling.
The highest water flows (≥ 1 l/carcass) were measured in plants 3A, 4 and 4A.

h) Chilling procedures

- Immersion chilling

3 plants (1, 2 and 4) practised a more or less developed counter-current immersion-chilling system, only one of them (plant 1)

using two separate tanks. Plant 4 used a typical one-unit counter-current chiller and plant 5* a so-called "drag" chiller.
The counter-current principle was not adequately used in plant 2 since the chill water was not replenished at the exit side (for birds) but at approximately two third of the length of the tank only.

Plant 5 practised a two-unit through-flow immersion chilling-system.

Further specifications are given on p. 4 and 5 of the annex.
Some main differences in the operation of the chilling system consisted in : - The way of providing agitation :

In one plant only (plant 5) the water was not agitated by compressed air. In plant 1, 2 and 4 carcasses were transported by a rotating screw. At plant 5, 1st unit agitation was provided by means of a rotating drum while in plant 5, 2nd unit, transport of carcasses was obtained by rotating paddles. Plant 5* used a "drag system" for transporting the birds.

- The water temperature and water flow :

Water temperatures and water flows were repeatedly measured during the experiments. In some plants flow-meters and temperature recorders were fixed for continuous registration. The average values with the standard deviation (S_1) are given on p. 4 of the annex.

Average temperatures, renging from 0.4° (plant 5) to 8.4°C (plant 2) at the exit side of the different chilling systems, were highly influenced by the water flow and the addition of ice to the chiller water or to the use of chilled water (plants 1 and 4).
The relatively high average water temperatures in plant 2 may probably be the result of the extremely low water flows (total flow of 0.28 L/carcass) (*).
The very low water temperature in the through-flow chiller (plant 5) is undoubtedly caused by the combination of a high total water flow (6.13 1/carcass) and the addition of considerable amounts of ice (1.9 kg/carcass).

- Residence times of carcasses :

Total average residence times, measured on 160 marked birds (8 x 20 carcasses) ranged from 18 min. (plant 5) to 91.8 min. (plant 1, 4th day of the experiment).

(*) : Due to the absence of a flow meter, water overflow could not be measured exactly. As stated by the plant manager, a flow of approx. 2.5 1/carcass should have been used at the time of the experiment.

- Air chilling

In 4 plants the carcasses were rehung on appropriate racks either by the legs (4A, 5A), the wings (3* A), or the abdominal cavity(3A).

In one plant (1A) 2 consecutive carcasses each were hanging by one leg on each shackle of the post-eviscerating line.

In one plant only (2A), carcasses were calibrated and ranged in plastic trays prior to chilling, the trays being placed on pallets in the chilling room. Drying in hot aire was practised prior to chilling in plant 2A. From the specifications on air temperatures, air velocities, conditioning and residence times of carcasses given on p.8 of the annex, it is evident that the chilling procedures applied in plants 1A and 2A considerably differed from those applied in all other plants, either by differences in carcass residence time or/and in the construction of the chiller.

Although in plant 3A chilling was performed in 3 consecutive stages, the general concept of the chilling system was similar to those of all other plants using a continuous air chilling tunnel (plants 3*A, 4A and 5A).

On emerging from the chilling tunnel, the carcasses usually had a dry appearence. In plant 4A the neck skin even showed slight crust freezing.

i) Post treatment (cf. annex table 1 and 2)

-Immersion-chilled carcasses

In contrast to all other plants, carcasses in plant 5* as they were removed from the chiller and hung on the drip-line, passed once again through a single-nozzle spray-washer.

Except for plant 2 practising only very short dripping times (20-30 sec.), carcasses were allowed to drain for a more suitable period of time ranging from 323 sec. (plant 1) to 403 sec. (plant 5*). Giblets packed either in plastic or paper bags, were inserted before carcasses were weighed and packed.

Plants 2 and 4 only disposed of a full-automatic calibration system (MOBA) avoiding any manipulation of the carcasses by hands. In the other plants (1, 5 and 5*) carcasses were manually placed on weight scales. Furthermore, plant 1 disposed of a particular calibration system (MOBA) whereby the carcasses fell from the scales through skids into a constantly running

broad rubber conveyer at the end of which the carcasses from the different weight groups are pressed together.

In plants 1, 2 and 4 carcasses were manually put into plastic bags by use of a bagging cone.
Accumulation of unpacked carcasses at the packaging stations was neglectible for all plants. After immersion chilling all carcasses were blast-frozen without any delay.

- Air-chilled carcasses

Subsequently to the chilling process, carcasses in plant 2A were usually stored for 1 to 2 days in refrigerated rooms at ± 0°C prior to packaging. Air temperature in the packaging station of the latter plant was kept below +10°C.

In contrast to the immersion-chilled carcasses, air-chilled carcasses were either placed on separate trays and subsequently wrapped with plastic foils (plants 1A, 2A, 4A and 5A) (1) or packed into paper coated wooden crates (plant 3A) or into polystyrene boxes (plant 3*A), both packaging types containing 8 to 10 carcasses each.
Average staying times of carcasses at the packaging stations ranged from approximately 4 1/2 min. (plant 4A) to 40 min. (plant 2A). In plant 1A, however, because of inadequate capacity in the packaging room, individual staying times of more than 312 min. were occasionally measured.

Subsequently to packaging, all air-chilled birds were removed to refrigerated storage to be sold in a fresh state.

B- Sampling and experimental procedures

a) General aspects

Besides an evaluation of cleaning and disinfection procedures before start of operation, bacteriological and physical examination of carcasses as well as bacteriological, physical and chemical tests were carried out on water supplies, scalding- and chilling water. Temperatures and velocities of air in the air-chilling systems were also measured.

In order to establish operating conditions in the different plants and their impact on bacteriological and physical aspects of the carcasses corresponding as close as possible to those for usual operation, experiments were carried out during two consecutive weeks on

(1) At plant 5A carcasses were put into plastic bags, not onto trays

two consecutive days each for all plants included in the study. Furthermore, all experiments as well as the major part of the measurements and checkings were made twice a day.

Consequently, the experimental plan included 8 experimental periods covering 4 days and 2 weeks respectively, for each of the plants involved in the present study.

b) Bacteriological procedures

1. Evaluation of cleaning and desinfection of equipment

Each day of the experiment, before start of operation, contamination of the equipment and working surfaces was checked either by contact plates or by swabbing. A survey of the procedures used and the key for evaluation of the results from the different plants is given in the following table:

Plant	Sampling technique	Media and Incubation	Evaluation of the results
1, 1A	Contact plates (NUNC) Ø 57 mm surface: appr. 25 cm^2	Plate Count Agar 48 hrs at room temperature	Microbiological limit: 100 col./plate
2, 2A	Contact plates Ø 57 mm surface: appr. 25 cm^2	Plate Count Agar 48 hrs at 30°C	Class 1 to 7 1: 0-5 colonies 2: 20 colonies 3: many scattered col. 4: fairly numerous col. 5: numerous colonies 6: uncountable but no confluent growth 7: confluent growth
3A, 3*A	Contact plates (RODAC, "Falcon") Ø 56 mm surface: appr. 24 cm^2	Plate Count Agar 48 hrs at 30°C	Enumeration of colonies per plate . Proposed limit: < 4 col./cm^2 Presented by the number of colonies/cm^2.
4, 4A	Swabs of a surface of ca. 10 cm^2, streaked on the surface of the agar media	Plate Count Agar 40 hrs at 30°C	Code: 0 to 4 0: < 5 col./plate 1: 5-15 col./plate 2: 16-49 col./plate 3: 50-500 col./plate 4: 200-uncountable

contd. p.11

5, 5A, 5*	Swabs o 10 cm^2 (in case of flat surfaces), streaked on the surface of agar media	Plate Count Agar 72 hrs at 30°C	key: 0 to +++ 0: no growth +: 100 col. or more ++: uncountable but single colonies visible +++: confluent growth

TABLE 2 : Techniques used for the evaluation of cleaning and desinfection procedures of the equipment in slaughtering plants.
Checkings were carried out once a day before start of operation.

No cleaning and desinfection of slaughter- and chilling equipment was carrried out during or between the experimental periods of the same day.

2. Examination of carcasses

During each of the 8 experimental periods, neck skin samples were taken on the line at 5 different stages, e.g.

- after plucking = 1st sampling stage
- after evisceration (before spray-washer) = 2nd sampling stage
- after spray-washing (before entering the chiller) = 3th sampling stage
- after chilling (at the exit side of the chiller) = 4th sampling stage
- after packaging (before storage) = 5th sampling stage

Only in plants 3A and 3*A, the 5th sampling stage was omitted.
The first series of samples (1st sampling stage) was taken after approximately two hours of operation in order to allow an equilibration of the hygienic condition of the processing line.
Except for plants 3A and 3*A, where 4hrs and 1hr intervals, resp., were introduced between the two consecutive experimental periods of the same day, a two hours interval occured between samplings on equivalent stages of two consecutive experimental periods each.

2.1°) Sampling procedure

At each of the 5 stages, 10 neck skin samples (approximately 10 g) were taken aseptically. At only two exceptions (plants 5, 5A and 5*, 1st sampling stage) birds were not removed from the processing line for sampling. The samples were taken at intervals corresponding to the passage of approximately 100 carcasses at each

stage.

For a comparative examination of salmonella-contamination before and after chilling, a series of neighbouring carcasses was tagged to permit identification following passage through the chilling systems. Cross-contamination studies, using salmonella-free and salmonella-infected flocks were not included in this experiments.

Apart from some exceptions, birds slaughtered during the first and the second experimental period of the same day were delivered from different broiler houses. However, birds slaughtered during one experimental period belonged to the same flock.

2.2°) Conditioning and treatment of samples

Treatment and conditioning of neck skin after sampling in the different plants are summarized in the following table:

Plant	Recipient	Transport to the laboratory	Storage Time	Storage Temperature	Homogenisation Device	Homogenisation Time
1, 1A	Sterile plastic bags	no	examined within 10 min. after sampling		Stomacher (buffered peptone)	1 min.
2, 2A	Sterile screw capped bottles containing 90ml buffered peptone water	yes	18-24hrs	Refrigerated isothermic container during transport. +2°C overnight	Stomacher (buffered peptone)	3 min.
3A	Sterile plastic bags	yes	7-8hrs	15min. at -18°C (for nonchilled samples only) folowed by storage in isothermic container at 0° +1°C	Stomacher (buffered peptone)	3 min.
3*A	Sterile plastic bags	yes	6-7hrs	Isothermic container at 0° ±1°C	Stomacher (buffered peptone)	3 min.
4, 4A	Sterile plastic bags	yes	3-5hrs	Refrigerated isothermic container	Stomacher (buffered peptone)	1 min.
5, 5A 5*	Sterile plastic bags	no	examined immediately after sampling		Stomacher (buffered peptone)	2 min.

TABLE 3 : Conditioning and treatment of skin samples following sampling in the slaughtering plants.

In plants 1, 1A, 5, 5A and 5* bacteriological examinations were carried out on the spot. For all other plants, due to transport and/or storage, examination of neck skin samples was delayed for 3 hrs (plants 4, 4A) up to 24 hrs (plants 2, 2A).

2.3°) Quantitative bacteriological examination

- Pooling of samples

From each of the 10 macerated skin samples, collected during the consecutive sampling stages, 1 ml was transferred into a sterile flask in order to obtain 1 pooled sample of 10 ml. Two series of decimal dilutions were made in a 0.1% peptone-saline fluid, with exception of the 3A and 3*A plants, where a single series of dilutions was made.

- Enumeration of total counts

Suitable dilutions were plated in duplicate (surface platings) on Plate Count Agar and incubated at 30°C for 48 hrs. Total counts per gram were expressed by the arithmetic average of both duplicates.

- Enumeration of coliform organisms

As for total counts, suitable dilutions were plated in duplicate by surface plating. The number of coliform organisms per gram was expressed by the average of both countings on Violet Red Bile Agar incubated at 37°C for 24 hrs.

2.4°) Qualitative bacteriological examination

Salmonella isolations were carried out on the remaining homogenates. These were not pooled, but examined individually. The homogenates were incubated at 37°C for 24 hrs as pre-enrichment. Enrichment, isolation and identification procedures were carried out according to the EEC-procedure for salmonella-isolation (doc. 3764/VI/73). The number of salmonella-positive samples was recorded.

3. Examination of water in contact with birds

3.1°) Sampling procedure

- Tap water used in contact with birds was sampled once a day (= 4 samplings for each plant).

- Water in the scalding- and chilling tanks was

collected during each of the experimental periods (= 8 samplings for each plant at both, the entry- and the exit side).
However, when the scald tanks were so constructed that the entry- and exit side of the birds were the same, water samples were taken at the entry-exit side and at the longest distance from the entry-exit side, with exception of plant 3A, where samplings were made only at the entry-exit side.
When two-unit immersion-chilling systems were used, samples were also taken at the entry- and exit side of both units.

3.2°) Quantitative and qualitative bacteriological examination

- Tap water was examined for total counts (in 1 ml) and coliform counts (in 100 ml) following usual techniques applied in the different Institutes.

- Scalding- and chilling water was also examined for total and coliforms counts (in 1 ml) using the same techniques as described for the examination of neck skin.

3.3°) Chemical analysis

Next to the bacteriological examination, all water samples were analyzed for total residual chlorine to check whether hypochlorination of the water has been omitted.
The choice for the analytical procedure was left to the participating Institutes.

c) Physical procedures

1. Physical measurements on carcasses

1.1°) Residence times

-Once a day residence times during scalding, plucking and spray-washing before and after evisceration were measured on 10 marked birds each.

-Residence times in the chilling systems were measured twice a day, i.e. during each of the experimental periods, on 20 marked carcasses each. If carcasses were passing through more than one chilling unit, residence times for each unit were measured separately, with the exception of plant 3A.

1.2°) Average temperature

During each of the 8 experimental periods, carcass temperature was determined at each of the 5 consecutive sampling stages (cf. page 11) by means of the average temperature.
For measuring the average temperature, 10 carcasses each were placed into an insulated box of appropriate size, the temperature being registered by thermocouples inserted among the carcasses in the center of the box. Registration was made after an equilibration period of 30 minutes.
However, in plant 3A, carcass temperature was measured exceptionally by direct insertion of thermocouples in the deep breast musculature.

1.3°) Changes in weight during chilling

Weight changes due to chilling were measured during the 8 experimental periods on 20 carcasses each, tagged and weighed prior to spray-washing and weighed again at the end of the drip line for the immersion-chilled birds, or at the exit of the chill tunnel for air-chilled birds.

In plant 4, water uptake due to spray-washing only, was also measured (cf. annex, figure 8).

In plant 5, apart from the total water uptake during spray-washing and chilling, the amount of water absorbed in the first and the second tank of the two-unit chilling system was measured separately.

2. Physical measurements on water and air in contact with birds

As already mentioned by the description of processing techniques, technical data concerning temperature and flow of water in contact with birds during the consecutive processing stages, were measured during each of the experimental periods.

Where feasible, measurements were made by automatic recording throughout the experiments.

In the air-chilling systems, temperature and velocity from in- and outcoming air as well as among birds in entry and exit parts of the chillers were measured.

III - EVALUATION OF THE RESULTS

A - Bacteriological examinations

a) Microbiological flow sheet analysis of equipment

Due to the different sampling techniques and/or varying evaluation of the results (cf. pages 10-11), some restriction should be made by comparing the results from the different plants.
However, from the results given in annex (cf. tables 3 to 11), some remarks may be made:

-Plants 1 and 1A (cf. annex, tables 3 and 4)

Employing a microbiological limit of less than 100 colonies per plate, it was found that for plant 1 on the first day of the first week 42% of the equipment did not meet this standard for cleaning and desinfection, to 19% on the second day of the first week.
On the first day of the second week 19% and on the second day of the second week 28% of the samples were beyond the limit of 100 colonies per plate. The results showed that cleaning and desinfection of the chill tanks, constructed of stainless steel, was no major problem.

Employing the same microbiological limit as above, it was found that for plant 1A 78% of the equipment did not meet the standard on the first day, for 49% on the second day, 65% on the third day and 41% on the last day, thus indicating less efficient cleaning and desinfection in the air-chilling plant than in the immersion-chilling plant.

-Plants 2 and 2A (cf. annex, table 5)

Comparing a series of photographs made from each of the seven microbiological classes with the bacteriological limits applied for the previous plants, 33 out of 48 sampled surfaces (=69%).
for plant 2 and 25 out of 32 (= 78%) for plant 2A apparently did not meet the standard for cleaning and desinfection applied for plants 1 and 1A.
The walls of the chiller tank were highly contaminated before start of operation.

-Plants 3A and 3*A (cf. annex, tables 6 and 7)

Premising an even distribution of the colonies on the surface of the contact plates, the proposed limit of < 4 colonies/cm^2

is equivalent to the limit employed for the evaluation of the results from the previous plants (<100 colonies/plate).

Employing this microbiological limit, from a total of 56 checkings carried out in each plant throughout the experiment, 37 (= 66%) did not meet the proposed standard of cleaning for plant 3A and 50 (= 89%) for plant 3*A.

-Plants 4 and 4A (cf. annex, tables 8 and 9)

Due to the different way of sampling and examination, the results presented in both tables are not comparable directly to those of the previous plants.

Although it should be noticed that yields are usually higher for swabs than for contact plates, swabs yielding 50 - 200 colonies per plate (code 3) may be approximately assimilated to a standard of 100 colonies on the surface of a contact plate.

In plant 4, 18 of the 24 checked surfaces (= 75%) at the fourth day of the experiment did not meet the employed standard for cleaning and desinfection.

These figures amounted up to 23 surfaces (= 96%) for the first day of the experiment to 24 (= 100%) of the surfaces for the second day and 22 (= 92%) for the third day of the experiment.

The greater part of the swabs which met the standard were taken from the chilling tank.

In plant 4A, 89%of the surfaces on the first and the third day the experiment showed a level of contamination beyond the employed limit, for 87% on the second day and 84% on the fourth day. The samples showing better bacteriological standards were mainly found at the packaging station.

-Plants 5, 5A and 5* (cf. annex tables 10 and 11)

In general, the standard for cleaning and desinfection of both plants (measured by swab samples) was high. Only few samples yielded counts which did not meet the proposed standard (100 colonies or more: code +).

The main exception was in case of the plucking machines. In plant 5, 5A, 7 out of 16 samples taken from the pluckers over the 4 days of the experiments gave counts of 100 colonies or more.

In plant 5*, the proportion was 2 out of 8. In plant 5* there was also a problem with the cleaning of the hock cutter and the compressed

air inlets to the immersion-chilling system showing less efficient cleaning for two days of the experiment each.

In general, it can be concluded that for most of the plants, the level of contamination of the equipment and working surfaces did not meet the employed standard for cleaning and desinfection. Even in the plants with a high standard for cleaning and desinfection, some parts of the equipment yielded high bacterial counts. Therefore, in the present study contamination of carcasses by micro-organisms remaining on the equipment has to be considered for all plants.

However, it should be pointed out that at this state, no common technique nor common standard for evaluating the level of contamination of equipment for slaughter of poultry has been accepted. Consequently, it cannot be concluded whether the surfaces which did not meet the arbitrary used standard, should also be classified as unsatisfactoty cleaned and desinfected.

b) Examination of water in contact with birds

1. Tap water (cf. annex, tables 12 and 13)

Results for viable counts show that for some plants (2, 2A and 4) water supply did not always meet microbiological standards for potable quality.
It is of interest to note that for water samples incubated at two different temperatures, counts at 20°C were higher than at 37°C. However, organisms appearing on plates incubated at 20°C may be potential spoilage organisms.

Residual chlorine was always below the level of detection. Data on residual chlorine were not available for plants 1 and 2.

2. Scalding water (cf. annex, tables 14 and 15)

Total and coliform counts for the different plants are presented by the log of the geomteric mean $\pm S_1$ of the counts measured during each of the experimental periods. As was to be expected, the lowest average counts were determined for plants 1, 2 and 4, practising high-scalding at temperatures near to 60°C. For plant 1, coliforms were never detectable in 1 ml. For plant 2, coliform organisms were present in one sample only (at the 5th experimental period); for plant 4, 7 out of 8 samples taken at the

entry side were positive for coliform organisms for 1 out of 8 samples only, taken at the exit side of the tank.
Moreover, salmonellae were isolated in the 100 ml sample taken during the first experimental period for plant 4 and in the 1 ml- and in the 100 ml sample taken during the fourth experimental period for plant 2.

All air-chilling plants and two immersion-chilling plants (5, 5*) practising a low-scalding procedure, resulted in higher average counts compared to the high-scalding procedure.
In two air-chilling plants, salmonellae were occasionally found in the 100 ml samples. In plant 2A, salmonellae were found on the fourth experimental period; in plant 4A, scalding water samples were positive for salmonellae on the first, the second, the fifth and the sixth experimental period.
Serotypes were different for each of the experimental periods.

For all plants, whether practising high- or low-scalding, residual chlorine was below the level of detection (< 0.1 ppm).

Referring to experiments carried out by German investigators showing that scalding water, artificially contaminated with S.typhimurium, was free for salmonellae after 30 min. at 60°C and after 2 hrs at 52°C, the results of this study support the findings from previous experiments, giving evidence of dissemination of salmonellae through the scalding water.

3. Chilling water (cf. annex, tables 16 and 17)

As for the scalding water, coliform and total counts at the entry- and exit side of the carcasses are presented by the log of the geometric mean $\pm S_1$ of the counts determined during the 8 consecutive experimental periods for each plant.
In comparison to the level of contamination at the entry side for the birds, counts were significantly lower at the exit side for plants 1, 2 and 4, practising the counter-current principle. Average total counts per ml at the exit side were not higher than log 2.92 for plant 1, log 3.61 for plant 2 and log 3.70 for plant 4.
Logs of average coliform counts ranged from 2.10 to 1.58 and 2.57, respectively.For plants 5 and 5*, however, no marked differences were measured in the counts throughout the chilling system. Analyzing the results for these both plants, it should be noticed that the level of contamination throughout the chilling tanks approximated the counts

measured at the exit side of the chilling systems from the three previous plants, indicating a high bacteriological standard. Furthermore, it is interesting to note that, except for plant 2 practising scalding near 60-62°C, total counts were higher for scalding water at the entry-exit side of the tank than for chilling water sampled at the exit side of the system.

On two experimental periods salmonellae were found in the 100 ml samples for plants 1 and 4.
In plant 2 three 100 ml samples from three different experimental periods were positive for salmonellae. On the fifth experimental period, salmonellae were found in the 1 ml- and in the 100 ml samples from both, the entry and the exit side of the immersion chiller.
It should be noticed that the serotypes isolated from the chill water in plants 2 and 4 were identical to those isolated from the scalding water.

For almost all experiments, residual chlorine in the chill water was below the level of detection. For plant 4 only, concentrations between 0.08 and 0.15 ppm could be measured during the second day of the experiment.

Considering the results of the bacteriological examination of the chilling water, it can be concluded that total and coliform counts at the exit side of the chilling system may be controlled either by practising counter-current of the chill water or by the usage of large amounts of water, preferably chilled below 5°C, in order to avoid accumulation of micro-organisms and particularly accumulation of coliform organisms in the tank.

The results also prove that an increase of micro-organisms upto 10^5/ml or more may be attributed to inadequate processing conditions.
Since salmonellae were occasionally isolated from the chilling water, dissemination of these organisms by the chilling water cannot be excluded.

d) Examination of carcasses

1.1°) General remarks

-Repeatability of laboratory procedures

As mentioned on page 13, the 10 neck skin samples,

collected at the 5 consecutive sampling stages from each of the experimental periods, were pooled prior to examination for total counts and coliform counts. Consequently, the results obtained by this technique are equivalent to the arithmetic average of ten individual counts. The repeatability of the laboratory procedures was checked by statistical analysis of all duplicate results for each plant separately. The coefficients of variation calculated on the logs of duplicate counts are presented in table below.

	Plant 1	Plant 2	Plant 4	Plant 5	Plant 5*
Tot. count	2.50	2.50	5.14	2.16	2.23
Colif. count	2.57	3.14	3.80	2.68	3.64

	Plant 1A	Plant 2A	Plant 3A	Plant 3*A	Plant 4A	Plant 5A
Tot. count	-	3.44	0.44	0.44	5.34	2.22
Colif. count	-	4.67	0.42	0.57	4.55	2.47

TABLE 4 : Coefficients of variation calculated on the logs of the duplicate counts.

For plants 3A and 3*A, coefficients of variation were very low (near or below 0.5 percent). However, it should be remembered that for these plants duplicate results for total and coliform counts were obtained from single dilution series. This probably explains the lower coefficients of variation observed.
For all other plants the coefficient of variation ranged from 2.16 percent to 5.14 percent for total counts and from 2.47 percent to 4.67 percent for coliform counts.
Duplicate results were not available for plant 1A.

-Presentation of the results and statistical evaluation

All further results will be presented by the log of the geometric averages $\pm S_1$ of the average counts obtained during the 8 experimental periods for the 5 consecutive sampling stages each.

Thus each figure in the tables is representing the average result of 8 x 10 samples = 80 counts.
Furthermore, the average coliform- and total counts $\pm SEM_1$ at the consecutive sampling stages are graphically spotted in a series of figures. To establish whether significant differences in neck skin contamination occured during processing, the average counts from consecutive stages were statistically analysed. Statistical analysis using the sign-test was performed on the average counts from each plant separately.

1.2°) Immersion-chilled carcasses

Summarized results for total and coliform counts are presented on pages 23 and 24 of the report (tables 5 and 6) and in annex (figures 1 to 5).

Stage 1 (= after plucking)

Average results and standard deviations for total and coliform counts presented on page 23, table 5, show a considerable variability not only between different plants but also between different experimental periods in the same plant.
In plant 5 only, little variation was found between total counts from the different experimental periods.
The lowest average counts for both, total and coliform organisms were obtained for plant 2, using the highest water temperature during scalding, thus indicating a benificial effect of high-scalding on surface contamination of broiler carcasses. For the same reason high bacterial loads for birds slaughtered in plants 5 and 5*, using low-scalding, may be explained.

In one plant, however, (plant 1) a relation between the scalding temperature and the bacteriological contamination of the scalding water on one hand and the total and coliform counts on the skin after plucking on the other hand, is not obvious. The high coliform counts on the skin in spite of absence of coliform organisms in the scalding water, may be caused only by a considerable recontamination in the plucking machines.
Moreover, it should be emphasized that other factors such as the amounts of water used during pluckin (little or no information available) and the introduction of an efficiently operated cleansing

	Plant	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
TOTAL COUNTS	1	5.24 ±0.48	5.42 ±0.59	5.15 ±0.55	4.51 ±0.52	4.72 ±0.63
	2	4.32 ±0.38	5.14 ±0.72	5.16 ±0.28	5.06 ±0.25	5.02 ±0.29
	4	4.43 ±0.59	5.44 ±0.47	5.00 ±0.32	5.14 ±0.60	5.15 ±0.44
	5	5.36 ±0.08	5.37 ±0.16	5.25 ±0.10	5.05 ±0.21	5.04 ±0.24
	5*	5.15 ±0.34	5.34 ±0.40	5.25 ±0.40	4.99 ±0.12	4.98 ±0.09
COLIFORM COUNTS	1	4.74 ±0.57	4.56 ±0.63	4.40 ±0.59	3.44 ±0.57	3.57 ±0.55
	2	3.41 ±0.33	4.02 ±1.12	3.70 ±0.30	3.29 ±0.43	3.10 ±0.37
	4	3.44 ±0.66	4.82 ±0.38	4.33 ±0.46	4.12 ±0.53	4.08 ±0.46
	5	4.50 ±0.56	4.62 ±0.34	4.24 ±0.19	4.03 ±0.19	4.23 ±0.39
	5*	4.21 ±0.18	4.59 ±0.60	4.59 ±0.48	4.08 ±0.22	4.14 ±0.24

TABLE 5 : Geometric means of bacterial counts (log N/g $\pm S_1$) at different stages of processing.

IMMERSION-CHILLING PROCEDURES

IMMERSION-CHILLING PLANTS

Plant		Stage 1—2	Stage 2—3	Stage 3—4	Stage 4—5
1	Tot. Counts	6 - 2 +	1 - 7 + *	8 + ***	7 - * 1 +
	Coliforms	3 - 5 +	2 - 4 + 2 =	8 + ***	4 - 3 + 1 =
2	Tot. Counts	7 - ** 1 =	5 - 2 + 1 =	3 - 5 +	4 - 4 +
	Coliforms	5 - 3 +	3 - 5 +	2 - 6 +	2 - 5 + 1 =
4	Tot. Counts	8 - ***	1 - 7 + *	4 - 3 + 1 =	4 - 3 + 1 =
	Coliforms	8 - ***	8 + ***	1 - 7 + *	5 - 3 +
5	Tot. Counts	4 - 4 +	1 - 7 + *	8 + ***	2 - 3 + 3 =
	Coliforms	6 - 2 +	8 + ***	1 - 7 + *	6 - 2 +
5*	Tot. Counts	5 - 3 +	3 - 4 + 1 =	1 - 7 + *	2 - 4 + 2 =
	Coliforms	6 - 2 +	5 - 3 +	8 + ***	4 - 4 +

TABLE 6 : Effect of consecutive processing stages on the bacteriological contamination of neck skin samples during the consecutive experimental periods (n = 8), evaluated by the sign-test.

Remarks: Results marked with (+): 7 experim. periods only
" " " *** : significant at 1% level
" " " ** : significant at 5% level
" " " * : significant at 10% level

Bacteriological contamination: - : negative effect (increase in counts)
+ : positive effect (decrease in counts)
= : no effect (unchanged counts)

of carcasses after plucking are to be considered for the interpretation of the variation between the initial counts of the birds from different plants. Spray-cleaning was operated in plants 1, 2 and 4.

Stage 2 (= after evisceration, before spray-washing)

Whereas the contamination of neck skin increased markedly in plants 2 and 4 only, the variability between the counts generally remained and even increased for some plants after evisceration had been carried out.
In plant 4 this increase was significant at a 1 percent level for both total and coliform counts (cf. table 6, page 24 and annex fig. 4).
In plant 2 the increase for total counts was significant at a 5 percent level (cf. table 6, page 24 and annex fig. 2).
For plants 1, 5 and 5*, counts did not increase to any marked extent. However, comparing the average counts on the eviscerated broilers from all plants, the level of contamination for plants 2 and 4 was at the same range as for plants 1, 5 and 5*. Otherwise, these results indicate that a marked increase in surface contamination occurred only in those birds were the counts prior to evisceration were relatively low (plants 2 and 4).

From the results it cannot be concluded whether spread of faecal contamination was better controlled by manual or mechanical eviscerating procedures.

Stage 3 (= after spray-washing, before chilling)

The effect of spray-washing on the contamination of the skin depends upon a number of technological factors summarized in annex, table 1 as well as on the extent of the attachment of the micro-organisms to the skin. In addition, the wash water always drains from the carcasses down into the neck skin with the result that the micro-organisms tend to accumulate in the region where the samples were being taken.

Nevertheless, spray-washing lowered neck skin contamination more or less markedly. Total counts decreased significantly at a 10 percent level in plants 1, 4 and 5; coliform counts decreased significantly at a 1 percent level in plants 4 and 5.

The effect of the spray-washing systems used in plants 2 and 5* was rather inconsistent since favourable as well as unfavourable

effects on the bacteriological contamination of neck skin samples were established throughout the 8 experimental periods. A survey of the effect of spray-washing (stage 2 —— 3) on the bacteriological condition, expressed in percent decresse (respectively increase) in the counts of the eviscerated birds, is given itable 7 on page 27.

Stage 4 (= after immersion chilling)

With respect to the total and/or coliform counts, a reduction could be observed after the carcasses had been passed through the immersion-chilling system of plants 1, 4 5 and 5*.
The decrease in coliform counts was statistically significant at a 1 percent level for plants 1 and 5* and at a 10 percent level for plants 4 and 5.

The reduction, in percent of the counts remaining on the neck skin after spray-washing immediately before entering the chilling system, is also summarized in table 7 on page 27. (cf. stage 3 —— 4).
The rinsing effect was most obvious for the two-unit counter-current chiller (plant 1) showing reductions of total and coliform counts ranging from 42 to 93% and from 75 to 94% respectively. Comparing the reduction rates established during spray-washing (stage 2 —— 3) and subsequent immersion chilling (stage 3 —— 4), it is obvious that, in general, after reduction of the counts by passing through a well operated spray-washer, a further substantial reduction of the remaining flora may occur.

Less favourable results, especially with regard to total counts, were obtained in plants 2 and 4. From 3 out of 8 experimental periods for plant 2 and from 4 out of 8 for plant 4, total counts were increased after passing through the chilling system. However, as already mentioned above, coliform counts were significantly decreased in the chilling system from plant 4.
Consequently, for one plant only (n° 2), no significant reduction, neither of total counts or of coliform counts, was found.
As indicated in table 1, plant 2 used only 0,28 litres of water per carcass during the period of experimentation. As indicated in the footnots on page 7 this plant would normally use 2.5 litres. Apparent-ly some operational irregularity occurred; it is not unlikely (contd.p.28)

		Plant 1		Plant 2		Plant 4		Plant 5		Plant 5*	
	Experim. period	Stage 2→3	Stage 3→4	Stage 2→3	Stage 3→4	Stage 2→3	Stage 3→4	Stage 2→3	Stage 3→4	Stage 2→3	Stage 3→4
TOTAL COUNTS	1	-55	-90	+86	+64	+30	-65	-50	-60	-20	-55
	2	-50	-52	-99	+21	-70	0	-37	-32	+82	-51
	3	+73	-91	+371	-67	-47	-24	-5	-76	-71	+127
	4	-67	-49	+295	-46	-94	+1851	-27	-26	+424	-90
	5	-69	-77	+63	-32	-47	+88	-35	-23	-10	-33
	6	-51	-42	+128	-41	-83	+100	-44	-4	-92	-19
	7	-17	-93	-8	-8	-56	-45	-38	-32	0	-39
	8	-55	-58	-1	+16	-42	+35	+92	-22	+22	-50
COLIFORM COUNTS	1	0	-86	+688	-93	-58	-66	-6	-58	+9	-63
	2	-57	-92	-99	-86	-78	-57	-5	-66	+77	-56
	3	+20	-75	-24	+303	-75	+144	-71	-10	-44	-16
	4	-55	-93	-84	+34	-79	-20	-21	-41	+1362	-95
	5	-49	-94	+96	-24	-64	-60	-55	-7	+57	-27
	6	0	-84	-48	-78	-73	-39	-80	-35	-98	-43
	7	-20	-92	+314	-82	-20	-61	-83	+5	-37	-29
	8	-37	-87	-90	-67	-69	-29	-71	-53	+209	-92

TABLE 7 : Increase (+) or decrease (-) in the bacteriological contamination in percent of the bacterial load present on the carcasses before spray-washing and chilling, respectively.

Stage 2→3 : Increase or decrease (in %) during spray-washing

Stage 3→4 : Increase or decrease (in %) during immersion chilling

IMMERSION-CHILLING PROCEDURES

that this accounts for the unfavourable results obtained in that plant. Some experts were of the opinion that the fact that such irregularities can happen in a modern plant employing water chilling indicates that some safe, foolproof controls are necessary to ascertain that water immersion chillers operate correctly at all times.

		Experim. period	Plant 1	Plant 2	Plant 4	Plant 5	Plant 5*
IMMERSION-CHILLING PLANTS	TOTAL COUNTS	1	-96	+205	-54	-70	-64
		2	-77	-98	-70	-57	-11
		3	-84	+55	-59	-77	-35
		4	-83	+13	+14	-46	-48
		5	-93	+10	0	-50	-40
		6	-72	+36	-67	-46	-94
		7	-94	-16	-76	-58	-39
		8	-81	+16	-22	+50	-39
	COLIFORM COUNTS	1	-86	-47	-86	-26	-60
		2	-97	-99	-90	-68	-23
		3	-70	+207	-39	-74	-53
		4	-97	-78	-83	-54	-27
		5	-97	+47	-85	-58	+14
		6	-84	-89	-83	-87	-99
		7	-93	-24	-69	-82	-55
		8	-91	-97	-78	-86	-74

		Experim. period	Plant 1A	Plant 2A	Plant 3A	Plant 3*A	Plant 4A	Plant 5A
AIR-CHILLING PLANTS	TOTAL COUNTS	1	-8	-75	-64	-53	-88	-67
		2	-76	-92	-49	-31	-95	-40
		3	-68	-81	-4	+621	-22	-10
		4	-77	-97	-52	-41	-64	+4
		5	-58	-50	-86	-35	+21	-15
		6	-70	-6	-50	-82	-54	+44
		7	-37	+1362	-60	+47	-79	-19
		8	-32	-83	+1	-55	-87	+75
	COLIFORM COUNTS	1	-3	+51	-79	-91	-90	-17
		2	-26	+51	-83	-25	-98	-5
		3	+2	+763	+238	+111	-41	-25
		4	+5	+43	-69	-82	-87	+11
		5	+41	-28	-47	+4	-80	+142
		6	-33	+67	-24	-95	-40	-69
		7	+100	-32	-37	+720	-30	-78
		8	-14	-82	-92	-79	-57	-65

TABLE 8 : Increase (+) or decrease (-) in the bacteriological contamination of carcasses due to spray-washing + subsequent chilling. Results are presented in percent of the bacterial load on carcasses before spray-washing.

considered as a preparative stage prior to chilling, unsatisfactory results for the experiment as a whole were obtained only for total counts from plant 2.
For all other plants, with the exception of one experimental period for plants 4, 5 and 5* showing a slight increase in coliform or in total counts, decrease in total counts ranged from 72 to 96% for plant 1, from 0 to 76% for plant 4, from 46 to 77% for plant 5 and from 11 to 94% for plant 5* (cg. page 28, table 8).
Decrease in coliform counts ranged from 70 to 97%, from 39 to 90%, from 26 to 87% and from 23 to 99% respectively.

Statistical analysis did not show any significant correlation between the washing effect and the level of bacteriological contamination of the eviscerated birds. Consequently, the main factors providing acceptable operating conditions were of physical nature, i.e. residence time of carcasses, water flow and temperature as well as the direction of the flow. Additionally, properly cleaning and desinfection of the equipment before start of operation may also not be neglected.
Residence times as such were of minor importance for the wash effect during immersion chilling, provided water temperature and water flow are adequately adjusted. In plant 1, the reduction of total and coliform counts was almost equivalent for residence times ranging from approximately 46.3 min. to approximately 91.8 min. In plant 5, using very short residence times (approximately 18 min.), the benificial effect of chilling may be attributed to a combination of a high water flow (approx. 6.13 l/carcass) and the addition of considerable amounts of crushed ice (approx. 1.9 kg/carcass) to the chill water of a two-step through-flow system.

Stage 5 (=after packaging)

Whereas in general, counts from the carcasses showed little further change during the packaging stages, in one plant (n° 1) a significant increase (at a 10 percent level) in total counts was found (cf. table 6 page 24 and annex fig. 1). Since an accumulation of unpacked birds did not occur at the packaging station of this plant and carcass temperatures were sufficiently controlled at a low level to avoid fast bacterial growth, the increase in total counts is probably attributable to improper operation or/and a low

hygienic standard of the equipment used for weighing and calibration of the birds.
Nevertheless, comparing counts from stages 3 and 5, it is evident that changes occuring at the packaging station did not affect the wash effect of spray-washing and immersion chilling in a perceptible way. Therefore, it may be concluded that significant decreases in total and coliform counts between the eviscerated and the chilled birds, remained upto final packaging.

Recently, some specifications for standard counts of frozen broilers were suggested by Dutch and German scientists, the former proposing a limit of 10^4 enterobacteriaceae in 1 gram of macerated abdominal skin. The German scientists, on the other hand, proposed standard counts for both total and enterobacteriaceae counts of not higher than 8 x 10^4/ml rinsing fluid and of not higher than 300/ml rinsing fluid, respectively. However, due to the different sampling techniques showing significant differences in recovery of micro-organisms, both standards are hardly comparable with the results obtained in the present study.
Therefore, an evaluation of the bacteriological standard of the final products from the present study by the specifications mentioned above, may lead to erroneous conclusions since in this study both, the site of sampling and the analytical procedures were so conceived that maximal yields for total and coliform counts had to be expected. Nevertheless, it may be presumed that the coliform standard for the neck skin samples frequently met the specifications for macerated abdominal skin.

1.3°) Air-chilled carcasses

Summarized results for total and coliform counts are presented on pages 31 and 32 of the report (tables 9 and 10) and in annex (figures 1A to 5*A).

Stage 1 (= after plucking)

As for the immersion-chilled birds, average counts for the various plants and standard deviations of the counts emphasize a high variability in the initial contamination of the birds. Initial counts were extremely high for the birds slaughtered in plants 3A and 3*A. Average total and coliform counts for these plants were at a log 6 range and at a log 5 range respectively.

	Plant	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
TOTAL COUNTS	1A	4.60 ±0.33	4.92 ±0.17	4.64 ±0.17	4.54 ±0.34	4.52 ±0.30
	2A	4.84 ±0.25	5.21 ±0.71	4.66 ±0.24	4.73 ±0.20	4.74 ±0.20
	3A	6.01 ±0.26	5.98 ±0.22	5.84 ±0.43	5.65 ±0.33	not examined
	3*A	6.22 ±0.21	6.24 ±0.19	6.39 ±0.21	6.12 ±0.44	not examined
	4A	5.13 ±0.45	5.76 ±0.44	5.26 ±0.33	5.15 ±0.41	5.42 ±0.30
	5A	5.36 ±0.08	5.37 ±0.16	5.25 ±0.10	5.37 ±0.30	5.15 ±0.28
COLIFORM COUNTS	1A	3.31 ±0.21	3.70 ±0.14	3.80 ±0.18	3.71 ±0.15	3.53 ±0.22
	2A	3.29 ±0.22	3.56 ±0.46	3.39 ±0.45	3.63 ±0.49	3.28 ±0.78
	3A	4.96 ±0.60	5.07 ±0.45	4.70 ±0.33	4.68 ±0.44	not examined
	3*A	5.51 ±0.46	5.57 ±0.41	5.66 ±0.42	5.23 ±0.59	not examined
	4A	4.26 ±0.61	5.06 ±0.69	4.49 ±0.40	4.41 ±0.35	4.88 ±0.47
	5A	4.50 ±0.56	4.62 ±0.34	4.24 ±0.19	4.44 ±0.23	4.19 ±0.18

TABLE 9 : Geometric means of bacterial counts (log N/g $\pm S_1$) at different stages of processing.

AIR-CHILLING PROCEDURES

AIR-CHILLING PLANTS

Plant		Stage 1→2	Stage 2→3	Stage 3→4	Stage 4→5
1A	Tot. counts	8 - ***	8 + ***	2 - 6 +	4 - 4 +
	Coliforms	8 - ***	6 - 2 +	3 - 5 +	1 - 7 + *
2A	Tot. counts	6 - 2 +	1 - 7 + *	4 - 4 +	3 - 5 +
	Coliforms	4 - 4 +	3 - 4 + 1 =	6 - 2 +	3 - 5 +
3A	Tot. counts	4 - 4 +	4 - 4 +	3 - 5 +	NOT EXAMINED
	Coliforms	5 - 3 +	1 - 7 + *	3 - 5 +	NOT EXAMINED
3*A	Tot. counts	4 - 4 +	6 - 2 +	1 - 7 + *	NOT EXAMINED
	Coliforms	3 - 4 + 1 =	5 - 3 +	1 - 7 + *	NOT EXAMINED
4A	Tot. counts	7 - * 1 +	1 - 7 + *	3 - 5 +	5 - (+) 2 +
	Coliforms	7 - * 1 +	1 - 7 + *	5 - 3 +	4 - 4 +
5A	Tot. counts	4 - 4 +	1 - 7 + *	5 - 3 +	1 - 6 + 1 =
	Coliforms	6 - 2 +	8 + ***	6 - 1 + 1 =	1 - 7 + *

TABLE 10 : Effect of consecutive processing stages on the bacteriological contamination of neck skin samples during the consecutive experimental periods (n=8), evaluated by the sign-test.

Remarks and key: cf. TABLE 6, page 24.

On the basis of the technical data from the initial processing stages no distinct reason for these high bacteriological counts was found.

Stage 2 (= after evisceration, before spray-washing)

In three plants (1A, 2A and 4A), average counts increased consistently during evisceration. This increase was significant at a 1 percent level for plant 1A only and at a 10 percent level for plant 4A only (cf. table 10 page 32 and annex figs. 1A and 4A).

In three other plants (3A, 3*A and 5A), total and coliform counts showed little evidence of any increase in carcass contamination during the evisceration stages which followed plucking.

Analogically to the results from the immersion-chilling plants, counts obviously increased only in these plants where the bacteriological contamination of the birds prior to evisceration was relatively low (plants 1A and 4A). The contamination of the plucked birds from plants 3A and 3*A prior to evisceration had already reached such a high level that additional contamination occuring during evisceration may fail to appear from the counts. On the other hand, the absence of spread of carcass contamination in plant 5A, may be attributed to the particular way of supporting the birds on the evisceration line, avoiding contamination of the neck skin by the intestinal contents (cf. page 6).

Increase in contamination, if occuring, could not be related to the fact whether evisceration was carried out manually (plant 1A)or mechanically (plant 4A).

Stage 3 (= after spray-washing, before chilling)

General remarks made on page 25, concerning a number of factors which may influence the effect of pray-washing on the bacteriological condition of the neck skin, are also applicable here. For that reason, the effect of spray-washing was found to be variable for some plants.

However, spray-washing significantly decreased total counts on carcasses from plant 1A (at 1 percent level) and from plants 2A, 4A and 5A (at a 10 percent level). A signinicant decrease in coliform counts was observed in plants 3A and 4A (at a 10 percent level) and in plant 5A (at a 1 percent level).

On the contrary, the cleansing effect of the spray-washer used in

	Experim. period	Plant 1A Stage 2→3	Plant 1A Stage 3→4	Plant 2A Stage 2→3	Plant 2A Stage 3→4	Plant 3A Stage 2→3	Plant 3A Stage 3→4	Plant 3*A Stage 2→3	Plant 3*A Stage 3→4	Plant 4A Stage 2→3	Plant 4A Stage 3→4	Plant 5A Stage 2→3	Plant 5A Stage 3→4
TOTAL COUNTS	1	-68	+182	-73	-7	-82	+97	+39	-66	-93	+71	-50	-33
	2	-63	-34	-90	-23	+38	-63	-10	-23	-90	-52	-37	-5
	3	-37	-49	-76	-23	-47	+79	+99	+262	-82	+337	-5	-5
	4	-45	-38	-96	-15	+23	-61	-39	-3	-68	+12	-27	+42
	5	-52	-14	-69	+61	-68	-56	+85	-65	+54	-21	-35	+31
	6	-39	-51	-13	+8	+131	-78	+67	-89	-50	-7	-44	+335
	7	-25	-17	+354	+222	+24	-68	+171	-46	-53	-55	-38	+31
	8	-42	+19	-87	+26	-51	+107	+20	-62	-19	-85	-92	+43
COLIFORM COUNTS	1	-17	+16	+23	+23	-74	-21	-51	-82	-93	+50	-6	-12
	2	+13	-34	-47	+184	-55	-62	-1	-24	-96	-50	-5	0
	3	-29	+44	+1	+755	-56	+661	+326	-50	-92	+669	-71	+161
	4	+14	-7	+65	-14	-46	-42	-91	+86	-89	+19	-21	+41
	5	+19	+18	-19	-11	-41	-9	+9	-5	-41	-66	-55	+433
	6	+20	-44	+21	+38	-37	+20	+5	-96	-44	+7	-80	+55
	7	+183	-29	-75	+166	+65	-62	+1155	-35	-50	+40	-83	+29
	8	+100	-57	-84	+13	-94	+26	+101	-90	+536	-93	-71	+19

TABLE 11: Increase (+) or decrease (-) in the bacteriological contamination in percent of the bacterial load present on the carcasses before spray-washing and chilling, respectively.

Stage 2→3 : Increase or decrease (in %) during spray-washing

Stage 3→4 : Increase or decrease (in %) during air chilling

AIR-CHILLING PROCEDURES

plant 3*A was most inefficient since total and coliform counts increased on respectively 6 and 5 out of the 8 experimental periods for that plant. Specifications on u age and pressure of water were not available.

A survey of the effect of spray-washing (Stage 2 → 3) on the bacteriological condition, expressed in percent decrease (respectively increase) in the counts of the eviscerated birds, is given in table 11 on page 34.

Stage 4 (= after air chilling)

In contrast with the immersion-chilled carcasses, consistent reduction in total and coliform counts was exceptionally observed for air-chilled birds. In plant 3*A, however, counts were reduced significantly at a 10 percent level. For this plant, however, it should be noticed that counts prior to chilling were extremely high. Even after chilling had been completed, counts were approximately 1 log higher than for birds from the other air-chilling plants.

By comparison with the immersion-chilled carcasses, the air-chilled birds generally had higher coliform counts whereas total counts were comparable after the birds had been passed through both chilling systems.

Because of the high variability between the counts prior to chilling, comparison of counts after chilling between the individual plants, either practising immersion chilling or air chilling, is not advisable.
However, counts from plant 5, 5A may be compared since the results were obtained on the same batches of birds, slaughtered and eviscerated on the same experimental periods. By comparison of the average counts from both, immersion- and air-chilled birds from the same plant, higher total and coliform counts were established for the air-chilled birds.

Stage 5 (= after packaging)

On some experimental periods for plant 4A, total and coliform counts markedly increased. However, for the experiment as a whole, this increase was statistically not significant (cf. table 10, page 32).
For all other plants, counts either remained unchanged or showed a

decrease with respect to the previous sampling stage. The reduction was significant at a 10 percent level for coliform counts from plants 1A and 5A only (cf. table 10 page 32 and annex figs. 1A to 5A).

Due to the reduction of total and coliform organisms in plant 5A, counts of neck skin after packaging of the birds were equivalent to those established prior to air chilling and also equivalent to those of the immersion-chilled birds after packaging. In relation to the occasionally observed decrease in counts during air chilling and packaging of carcasses, the question rises whether the observed decrease in fact is due to a real decontaminating effect or to other factors related to some deficiencies in sampling- and analytical techniques. Since on both processing stages no decontaminating action on the surface of the carcasses takes place, the latter supposition seems to be more likely.

Evaluating total results for air-chilled birds, the bacteriological standard of the packaged product was found to be highly related to the extent of contamination of the ingoing birds.

For some plants coliform standards for neck skin samples met the specifications proposed for macerated abdominal skin ($\leqslant 10^4$/g)

2. Qualitative bacteriological examination

Salmonella isolations on individual birds were included in this study to find out whether the extent of the contamination was increasing or decreasing during processing. Employing the sign-test on the data, comparing the number of positive carcasses between two consecutive stages for each plant individually, it was checked whether changes in the number of salmonella-contaminated carcasses were statistically significant or not.

2.1°) Immersion-chilled carcasses

Summarized results are presented in tables 12 and 13 (cf. pages 37 and 38) and in fig. 1 (cf. page 39).
A survey of the serotypes isolated from the birds is given in annex, table 18.

Stage 1 (= after plucking)

At all plants, salmonellae were recovered at least on one of the experimental periods. Considerable variation in the inci-

Plant	Experim. period	NUMBER OF SALMONELLA-POSITIVE SAMPLES Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
1	1	-	-	-	-	-
	2	-	-	-	-	-
	3	-	-	-	1	-
	4	1	-	-	-	-
	5	-	-	-	-	-
	6	-	-	-	-	-
	7	-	-	-	-	-
	8	-	-	-	-	-
	total	1	0	0	1	0
2	1	1	-	1	4	6
	2	-	-	-	-	2
	3	-	-	3	-	1
	4	-	-	-	-	2
	5	2	7	-	6	6
	6	7	-	2	9	7
	7	-	-	-	-	1
	8	-	-	-	-	1
	total	10	7	6	19	26
4	1	-	-	-	-	-
	2	-	-	-	-	-
	3	-	3	1	1	-
	4	-	-	-	-	2
	5	-	-	-	-	-
	6	-	-	-	-	-
	7	-	1	1	-	2
	8	1	2	2	-	1
	total	1	6	4	1	5
5	1	-	-	-	-	-
	2	-	-	-	-	-
	3	1	7	3	7	1
	4	2	2	-	-	-
	5	-	-	-	-	-
	6	-	-	1	-	-
	7	-	-	-	-	-
	8	2	1	-	-	1
	total	5	10	4	7	2
5*	1	-	-	-	-	-
	2	-	-	5	-	1
	3	-	-	-	-	-
	4	-	-	-	6	3
	5	10	10	10	9	10
	6	10	10	10	10	10
	7	5	-	-	-	1
	8	1	-	-	-	-
	total	26	20	25	25	25

TABLE 12 : Number of salmonella-contaminated neck skin samples (10g) at different processing stages. 10 Samples per experim. period.

IMMERSION-CHILLING PROCEDURE

	Plant	Stage 1→2	Stage 2→3	Stage 3→4	Stage 4→5
IMMERSION-CHILLING PLANTS	1	8 =	8 =	1 - 7 =	1 + 7 =
	2	1 - 2 + 5 =	3 - 1 + 4 =	3 - 1 + 4 =	6 - 1 + 1 =
	4	3 - 5 =	1 + 7 =	2 + 6 =	3 - 1 + 4 =
	5	1 - 1 + 6 =	2 - 3 + 3 =	1 - 1 + 6 =	1 - 1 + 6 =
	5 *	2 + 6 =	1 - 7 =	1 - 2 + 5 =	3 - 1 + 4 =
AIR-CHILLING PLANTS	1A	8 =	8 =	8 =	8 =
	2A	1 - 2 + 5 =	2 - 1 + 5 =	1 - 2 + 5 =	1 - 2 + 5 =
	4A	2 - 1 + 5 =	2 - 3 + 3 =	1 - 4 + 3 =	2 - 2 + 4 =
	3A	1 - 2 + 5 =	2 + 6 =	1 + 7 =	NOT EXAMINED
	3*A	6 - 1 + 1 =	2 - 4 + 2 =	4 + 4 =	NOT EXAMINED
	5A	1 - 1 + 6 =	1 - 3 + 4 =	2 - 1 + 5 =	1 - 2 + 4 =

TABLE 13 : Effect of the consecutive processing stages on the number of salmonella-contaminated neck skin samples during the consecutive experimental periods (n=8), evaluated by the sign-test.

Number of neck skin samples per experim. period = 10.

Remarks and key : cf. table 6, page 24.

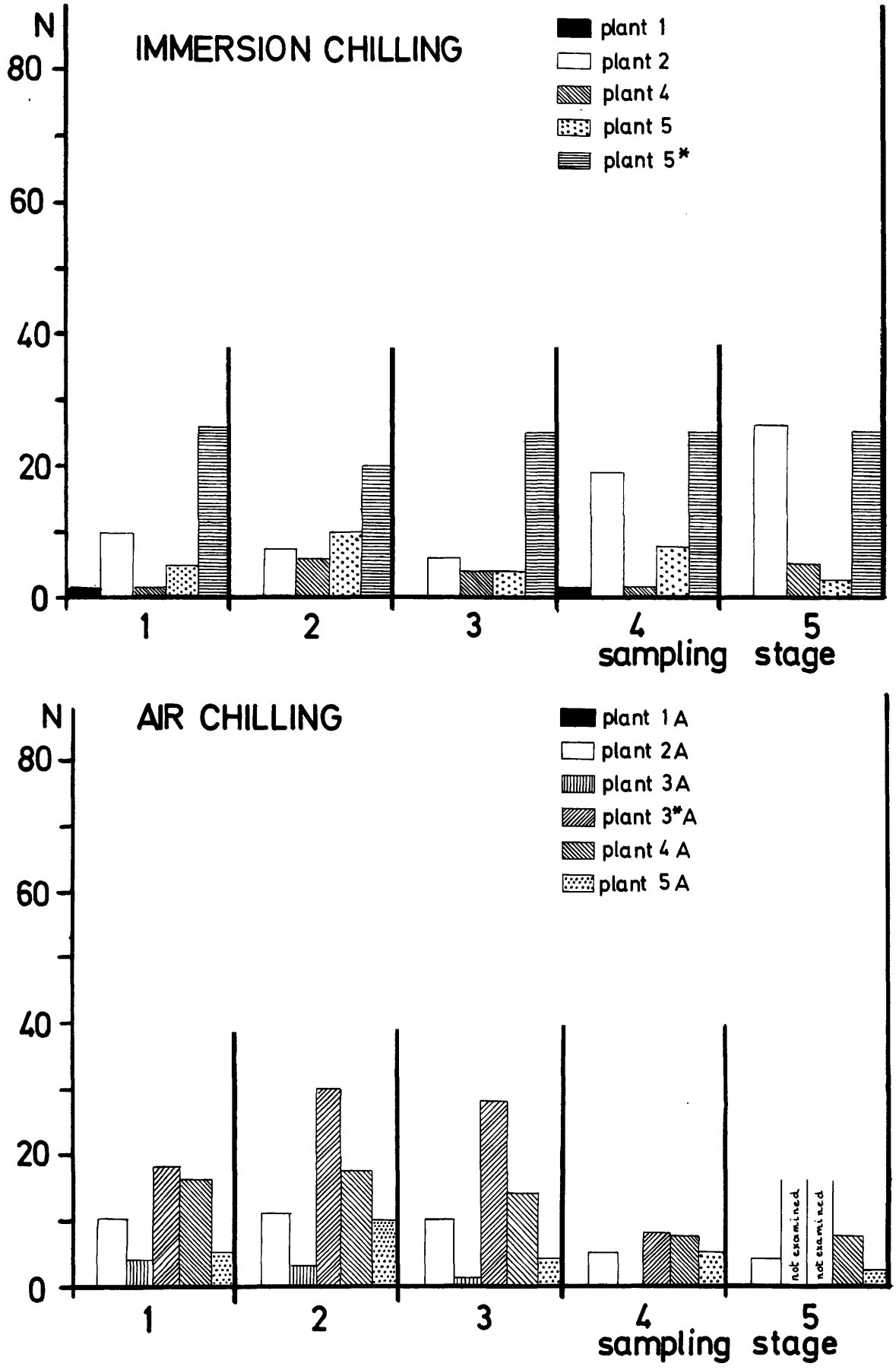

FIGURE 1 : Number of salmonella-contaminated neck skin samples at different processing stages during the consecutive experimental periods (n = 8).

Number of samples per stage : 8 x 10 = 80 (for each plant)

dence between the experimental periods was found.
A very high incidence was found on the 6th experimental period for plant 2 (cf. table 12 page 37) on which 7 out of the 10 sampled carcasses were positive, and on the 5th and the 6th experimental period for plant 5* (all ten carcasses positive).
For plant 1 and 4, on the other hand, salmonellae could be isolated from only one out of the 80 carcasses each, sampled throughout the experiment.

Stage 2 to 5 (= from evisceration upto packaging)

On some experimental periods only (e.g. on the 1st, the 5th and the 6th for plant 2; on the 3th and the 4th for plant 5; on the 5th and the 6th for plant 5*) the occurence of salmonellae was sufficiently high for those organisms to be detected at most of the processing stages. However, statistical analysis of the results did not show any significant increase or decrease between two consecutive stages for each plant individually.

For merely one plant (n° 2) the number of salmonella-contaminated carcasses increased markedly at the packaging station (stage 4 → 5): 6 out of the 8 experimental periods showed an increase in the number of positive samples.

Statistical analysis of the results gave no evidence of eventual hazard for dissemination or increase of salmonellae in a continuous immersion-chilling system.
Table 12 (cf. page 37) and figure 1 (cf. page 39) indicate that for one plant only (n° 2) the number of salmonella-positive samples was considerably higher after chilling (19 = 23.5%) than before chilling (6 = 7.5%). However, from table 12 it is also evident that this overall increase was only caused by the unfavourable results from the 3th day of the experiment. On this day, the chiller was obviously not well operated since water temperatures between 30 and 40°C were measured at the entry side of the tank.

In plant 5*, the batch of birds which was already extensively contaminated after plucking, did not show any reduction in the extent of contamination through further processing stages but salmonellae were not found in the water samples from the scald tank or from the chilling system. There was also no evidence for dissemination of salmonellae through the tank-water for that particular plant. This also applies to the examinations carried out

in plant 5.
On the other hand, during some of the experimental periods for plants 1, 2 and 4, one or more salmonella-serotypes predominating on carcasses at various processing stages either before or after chilling, were also isolated from scalding and/or chilling water samples.

A survey of the different serotypes isolated from birds of the various plants is given in annex, table 18.
In general, the results of serotypings show a predominance of one serotype for each day of the experiment. In all plants, however, additional serotypes were isolated on some of the experimental periods.

2.2°) Air-chilled carcasses

Summarized results are presented in tables 13 and 14 (cf. pages 38 and 42) and in fig. 1 (cf. page 39).
A survey of the serotypes isolated from the birds is given in annex, table 19.

Stage 1 (=after plucking)

Considerable variation was found in the occurence of salmonellae between the plants and between the experimental periods for the various slaughter plants.
Whereas salmonellae were not recovered at all in plant 1A, these organisms could be isolated on 5 out of 8 experimental periods for plants 3*A and 4A and on 3 out of 8 for plants 2A, 3A and 5A.
For 3 plants the incidence of salmonellae on the plucked birds was fairly high on one particular day, including 2 consecutive experimental periods, i.e. on the first day for plant 2A, on the second day for plant 4A and on the third day for plant 3*A. On these days approximately 50 percent of the plucked birds were carrying salmonellae (cf. table 14).

Stages 2 to 5 (= from evisceration upto packaging)

In plant 3*A, the number of salmonella-contaminated birds following evisceration (stage 1 → 2) increased on 6 out of 8 experimental periods. Evaluating the results for all plants, there was no significant increase or decrease in the number of salmonella-contaminated carcasses following evisceration and subsequent spray-washing (stages 1 to 3).

Plant	Experim. priod	NUMBER OF SALMONELLA-POSITIVE SAMPLES Stage 1	Stage 2	Stage 3	Stage 4	Stage
1A	1	-	-	-	-	-
	2	-	-	-	-	-
	3	-	-	-	-	-
	4	-	-	-	-	-
	5	-	-	-	-	-
	6	-	-	-	-	-
	7	-	-	-	-	-
	8	-	-	-	-	-
	total	0	0	0	0	0
2A	1	6	3	5	1	1
	2	3	8	4	1	3
	3	-	-	-	-	-
	4	-	-	-	-	-
	5	-	-	-	-	-
	6	-	-	-	2	-
	7	1	-	-	-	-
	8	-	-	1	1	-
	total	10	11	10	5	4
3A	1	2	-	-	-	not examined
	2	-	2	1	-	
	3	-	-	-	-	
	4	-	-	-	-	
	5	-	-	-	-	
	6	-	-	-	-	
	7	1	1	-	-	
	8	1	-	-	-	
	total	4	3	1	0	
3*A	1	1	2	-	-	not examined
	2	-	-	-	-	
	3	-	1	-	-	
	4	-	5	7	4	
	5	8	10	8	-	
	6	4	6	4	4	
	7	4	2	5	-	
	8	2	4	4	-	
	total	19	30	28	8	
4A	1	1	1	-	-	1
	2	1	1	1	-	1
	3	4	4	5	3	2
	4	8	4	6	3	2
	5	2	6	2	-	-
	6	-	1	-	1	1
	7	-	-	-	-	-
	8	-	-	-	-	-
	total	16	17	14	7	7
5A	1	-	-	-	1	-
	2	-	-	-	-	-
	3	1	7	3	3	1
	4	2	2	-	-	1
	5	-	-	-	1	-
	6	-	-	1	-	-
	7	-	-	-	-	-
	8	2	1	-	-	-
	total	5	10	4	5	2

TABLE 14 : Number of salmonella-contaminated neck skin samples (10g) at different stages of processing. 10 Samples per experimental period.

AIR-CHILLING PROCEDURES

Although for several plants the total number of salmonella-contaminated carcasses was reduced after air chilling, the results for the experiments as a whole were not found to be statistically significant.
No marked change in the incidence of salmonella organisms occurred during further packaging.

As already previously pointed out, a real decontaminating effect by passing through chilled air is most unlikely. Therefore, the established reduction of contaminated carcasses in some plants may be explained by methodological hazards related to the uneven distribution of salmonellae on the surface of the carcasses and/or by drying of the surface which may injure the recovery of the salmonellae present on the skin.

The comparison between air- and immersion-chilled birds at plant 5, 5A where birds from the same flock were subjected to the same treatment prior to chilling, did not show any difference in the number of salmonella-contaminated carcasses throughout the experiment. For both chilling systems, the total number of contaminated birds at the final stage was extremely low (2 positive carcasses each = 2.5%).

As for the immersion-chilled birds, one particular serotype was usually predominant for each experimental period and other serotypes were only occasionally identified.
In plant 3*A, however, 6 different serotypes were present on neck skin samples collected throughout the 7th experimental period.
In two plants (2A and 4A) 3 serotypes isolated from the birds, were also found in scalding water samples.
On many occasions, common serotypes were isolated on the consecutive experimental periods from one day. For some plants, either practising immersion chilling or air chilling, one particular serotype was predominant throughout the whole experiment. However, by lack of information regarding the extent of contamination of live birds and serotypes involved, it cannot be concluded whether the high incidence of these serotypes is attributable to infection of the ingoing live birds or to a carry-over from one experimental period to the next, respectively from one day or week to the next.

B - Physical measurements on carcasses

a) Average temperature

1. Immersion-chilled carcasses

Mean average temperatures after chilling were comparable for carcasses from plants 1, 4 and 5* (between approximately 7°C and 8°C). For plant 5, temperature of the chilled birds was averagely 1°C higher. However, on all experimental periods the average temperature dropped below 10°C (cf. table 15, page 46).
For plant 2 only, average temperatures upto 11°C were occasionally measured after chilling.

Whereas a slight increase occured at the packaging station from plants 1, 4 and 5*, carcass temperatures did not show any increase in plant 5. In all except one case (plant 5*, fourth experimental period: average temperature of packed product = 10.5°C), average temperatures of the packed product remained, however, below 10°C.
In plant 2, temperature measurements were not carried out at the packaging station.

2. Air-chilled carcasses

Except for plant 1A, the average temperature of the birds after chilling had been achieved, dropped below 10°C (cf. table 15). The chilling operation was most effective in plant 4A where average temperatures near to 0°C were already measured after a residence time in the chilling tunnel of 57 minutes.
For plant 2A, on the contrary, a final temperature of approximately 2°C was only measured after a storage period of 24 hours in the chilling room.
In plant 1A, the air-chilling equipment reduced carcass temperature only to approximately 12°C. The results for the latter plant indicate that the chilling conditions were rather poor.

Total results show that with both, air chilling and continuous immersion chilling, carcass temperature can de reduced within an acceptable period of time in order to avoid rapid bacterial growth on the surface of the product.

b) Changes in weight during chilling

1. Immersion-chilled carcasses

Average water-uptake $\pm S_1$ for carcasses chilled in

various immersion-chilling systems is given in table 16 (page 46). Additionally, the data for each separate plant are plotted in annex, figures 6 to 10.

Total average water-uptake during spray-washing and subsequent immersion chilling varied between the plants but was shown to be fairly constant throughout the consecutive experimental periods for most plants.

Water absorption was the lowest for the so-called "drag-chiller" (plant 5*), resulting in an average uptake of 4.1% with a standard deviation of 0.9% (cf. annex,figure 10).
Results obtained for plant 5, practising a two-unit through-flow chiller, also indicate that the weight gain of carcasses during spray-washing and immersion chilling was controlled at a very low level (average uptake of 5.31% with a standard deviation of 0.9%).
The greater part of the water was taken up on passing through the first unit (cf. annex, figure 9). The water-uptake during spray-washing was about 1.5%.
It should be noticed, however, that in both previous plants agitation of water was practised either not(plant 5) or in a limited way (plant 5*).

Total water-uptake during spray-washing and immersion chilling in plants 1 and 4 was on the average of 6.6% and 6.3% respectively with a standard deviation of 1.7% and 2.1% respectively. In contrast to the two former plants where water-uptake was within a 8%-limit, approximately 17 percent of the birds, chilled in plants 1 and 4, showed a water pick-up of more than 8%. Consequently, the variation in weight gain between individual birds was also higher (coefficients of variation of resp. 25.5 and 33.1%) than for birds from plants 5 and 5* (coefficients of variation of resp. 16.6 and 22.2%).
In plant 4, water pick-up during spray-washing amounted upto approx. 1.3% (cf. annex figure 8).

In plant 2 only, average water-uptake exceeded 8.0% (i.e. 8.89% with a standard deviation of 5.6%). The high coefficient of variation of 63.7% indicates a considerable variation in water-uptake between individual birds. Almost 40 percent of the birds had a water-uptake upward 8%. Occasionally, water pick-up exceeded 20% of the initial weight prior to spray-washing.

Summarized results for all plants suggest that water-uptake during continuous immersion chilling of poultry carcasses

Plant	Stage 2	Stage 3	Stage 4	Stage 5
1A	27.50 ±1.73	26.25 ±1.26	12.20 ±0.82	13.38 ±1.49
2A	30.50 ±2.14	32.50 ±1.64	2.00 ±1.22	3.44 ±0.82
3A	39.83 ±0.20	38.81 ±0.27	8.21 ±0.47	not measured
3*A	28	27	5	not measured
4A	34.36 ±0.89	32.12 ±0.95	0.25 ±0.62	2.83 ±1.16
5A	34.00 ±1.94	32.00 ±1.08	7.64 ±1.21	8.00 ±1.15
1	30.50 ±0.58	29.50 ±0.58	7.25 ±0.50	9.25 ±0.50
2	31.63 ±1.92	26.63 ±1.69	10.05 ±0.78	not measured
4	28.64 ±1.32	27.50 ±1.13	7.71 ±0.56	9.28 ±0.25
5	34.00 ±1.94	32.14 ±0.99	8.93 ±0.67	8.71 ±0.49
5*	30.00 ±0.93	28.38 ±1.33	7.81 ±1.03	9.13 ±0.74

TABLE 15: Average temperature of poultry carcasses (± S_1) at different stages of processing. Temperature measured in °C.

Measurements in plant 3A are made by direct insertion of thermocouple in the deep breast musculature.

Stage 2 = after evisceration
Stage 3 = after spray-washing
Stage 4 = after chilling
stage 5 = after packaging

Plant	1	2	4	5	5*
IMMERSION CHILLING	+6.6 ±1.7	+8.9 ±5.6	+6.3 ±2.1	+5.3 ±0.9	+4.1 ±0.9

Plant	1A	2A	3A	3*A	4A	5A
	-0.5	-0.8 ±0.3	-0.7 ±0.04	-0.7 ±0.1	-0.04 ±0.01	-0.4±0.3

TABLE 16: Differences (in percent of initial weight ±S_1) between weighings before spray-washer and at the exit of the chiller, including usual dripping times for immersion-chilled birds.

can be controlled at a low level. However, unsuitable processing conditions may represent a hazard for uncontrolled water-uptake. Apart from eventual skin damage, the weight gained during chilling may be influenced by a number of factors such as the duration of the water treatment, agitation and temperature of tank water. However, the results suggest that agitation and temperature of the chill water has been one of the major factors in controlling water-uptake. From the specifications given in annex, table 1, it is obvious indeed, that lowest water pick-ups were measured in those chilling systems using the lowest chill water temperatures (plants 5 and 5*). On the contrary, the highest pick-up of chill water was obtained in the chilling system which operated at a relatively high water temperature on the entry side of the tank (plant 2). Residence time seemed to be of minor importance in this study.

2. Air-chilled carcasses

In contrast to the immersion-chilled birds, carcass weight was slightly reduced after air chilling. Loss of weight ranged from 0.04% (plant 4A: air blast tunnel, residence time of 57 minutes) upto 0.8% (plant 2A: chilling room, residence time of 6 hours).

These results show that water picked-up during spray-washing mainly consisted in surface moisture which completely evaporated during subsequent air chilling.

IV - DISCUSSION AND CONCLUSIONS

A) General remarks

Referring to the mandate given by the Commission, i.e. to evaluate the hygienic problems related to different chilling procedures of poultry carcasses, the present study and the discussion of the results mainly dealt with this aspect of poultry processing.

Consequently, the general conclusions drawn from the results of the experimental work will also refer mainly to this particular item. Nevertheless, in order to relate the effect of chilling on the bacteriological condition of the carcasses to some processing stages of industrial slaughter preceeding or following the chilling operation, brief comments will be given on the influence of some of these factors which were also investigated in the present study.

Apart from the bacteriological implications of slaughter-and chilling procedures, some conclusions concerning the rate of chilling in the different chilling systems, will also be drawn from the results of the present study.

Finally, conclusions will be drawn with regard to the relation between changes in weight during chilling of carcasses and the type of chilling system used.

Where scientifically justified, attempts will be made to link contingent changes in the bacteriological and physical condition of the carcasses between consecutive processing stages to the hygienic standard of the different plants as well as to specifications concerning the construction and operation of the equipment used at the corresponding processing stages.

B) Technical data of operation of equipment for slaughter and chilling

Throughout the experimental work, technical data including temperature, pressure and usage of water in contact with birds as well as residence times and average temperatures of carcasses were collected during operation of the equipment.

Special attention was paid to collect all technical data required for detailed specification of the washing- and chilling procedures of the birds.

Although only some investigators used recording devices for continuous survey, all procedures from slaughter up to packaging were sufficiently characterized to make an objective evaluation of the techniques which have been applied in the different plants. However, there was an almost general lack of information on the usage of water during plucking of birds.

On the basis of the specifications from the chilling procedures which were applied, the plants may be divided in two main groups, i.e. a first group of plants practising air-chilling procedures (plants 1A, 2A, 3A, 3*A, 4A and 5A), and a second group practising water-chilling procedures (plants 1, 2, 4, 5 and 5*). Moreover, both types of chilling can be subdivided as follows:

-AIR-CHILLING PLANTS:

- -carcasses individually supported on a conveyer passing through an air blast tunnel (plants 3A, 3*A, 4A and 5A)
- -carcasses individually supported on a conveyer passing through a chilling room (plant 1A)
- -carcasses ranged in plastic prays being placed on pallets in a chilling room for 6 hours (plant 2A)

-IMMERSION-CHILLING PLANTS:

carcasses were passing through a

- two-unit counter current system (plants 1 and 2)
- one-unit so-called "drag" chiller (plant 5*)
- two-unit through flow system (plant 5)
- one-unit counter current system (plant 4)

Technical data on the way of operation indicated that the one-unit counter current system from plant 2 was not properly operated since measured temperature and usage of chill water were inadequate. Furthermore, dripping times of carcasses between chilling and packaging were extremely short (20 to 30 sec.)

On the other hand, the highest amounts of chill water were used in plant 5 (more than 6 1/carcass). Moreover, considerable amounts of ice (approx. 2 kg/carcass) were added to the chill water of this plant. Some doubt was raised by an expert whether the use of such large amount of ice and water may be a regular practice under normal operating conditions. From the remaining plants, plant 5* only also practised the addition of crushed ice to the chill water.

In all plants, air-chilled birds were low-scalded after killing by passing through a water bath at average temperatures ranging from approximately 50 to 53°C.

The immersion-chilled birds were either high-scalded at temperatures between approximately 59 and 63°C, or low-scalded at temperatures between approximately 50 and 53°C.

In industrial plants high-scalding is generally practised in combination with immersion chilling, whereas low-scalding procedures are used for air-chilled birds.

The way of operating, the construction of equipment for plucking and the application of singeing are also related to the scalding temperature. Therefore, the number of pluckers and hence the plucking times for carcasses are usually higher for low-scalded than for high-scalded birds.

Singeing, if applied, is only common for low-scalded birds (cf. plants 3A and 3*A).

Due to the removal of the epidermis, high-scalded carcasses are generally considered unfit for chilling in air (discoloured skin). For that reason, they are, as a rule, chilled in water and subsequently stores in a frozen state (cf. plants 1, 2 and 4). On the other hand, air-chilled birds which have been low-scalded are usually kept in a refrigerated (fresh) state (cf. plants 1A, 2A, 3A, 3*A, 4A and 5A), while low-scalded birds, which have been water-chilled may be stored in a frozen state (cf. plants 5 and 5*).

For all other processing stages no major differences occur in the handling and treatment of carcasses which are to be sold either in a fresh or in a frozen state.

C) Hygienic standard of the equipment before start of operation

For lack of a general accepted technique and standards for the evaluation of cleaning and desinfection of equipment and working surfaces, the choice of the most appropriate checking procedures was left to the scientific groups from each of the cooperating Institutes.

Although a comparision of the results gave some evidence for different standards of desinfection between the plants as well as between the different experimental days for one plant, differences were not related

to the type of plant (air chilling or immersion chilling).

Using results of $\leq$ 100 colonies on the surface of Plate Count Agar-contact plates (contact surface of approximately 24 cm^2) or an equivalent value when practising other sampling procedures, as an arbitrary standard, the level of bacteriological contamination on most of the equipment and working surfaces from most plants did not meet the standard before start of operation. However, for lack of common methods and standards it cannot be concluded whether the values which exceeded the given standard should be considered as unsatisfactory cleaned and desinfected.

Compared to other types of equipment and working surfaces, cleaning and disinfection of immersion-chilling tanks was no particular problem in plants 1, 4, 5 and 5*.

Only for plant 2, the walls of the chilling tank were highly contaminated before start of operation. In this plant, however, samplings on other sites along the slaughter- and viscerating line generally indicated a low hygienic standard of the equipment before start of operation.

D) Bacteriological, chemical and physical characteristics of water in contact with birds

a) Tap water

For all plants residual chlorine was below the level of detection ($<$0.1 ppm).

However, results for viable counts showed that for some plants (e.g. 2, 2A and 4) water supply did not always meet common microbiological standards for potable water.

These findings indicate that checking of the bacteriological condition of tap water should be included in the procedures for controlling the hygienic status of poultry processing plants, in order to ensure water supplies which meet common standards for potable water.

b) Scalding water

Counts for total and coliform organisms were lower for high-scalding- (plants 1, 2 and 4) than for low-scalding procedures, thus indicating a beneficial effect of higher water temperatures on the bacterial load of the scalding water. When practising high-scalding procedures, coliform contamination of the scalding water at the exit side of the birds further decreased

When the entry- and exit side of the scalder were located at different sites of the system (cf. plant 4).
Occasionally, salmonellae were isolated from the scalding water. Even high-scalding at temperatures up to 63°C did not completely eliminate salmonellae from the scalding water. Consequently, this fact confirmed the findings from previous experiments giving evidence of dissemination of salmonellae through the scalding water.

For all plants, residual chlorine was below the level of detection.

c) Wash water

Spray-cleaning of birds immediately after plucking was used in 3 out of the 5 immersion-chilling plants (1, 2 and 4) for only one (plant 3A) of the plants practising air-chilling procedures.

Immediately after evisceration, before entering the chilling system, spray-washing of carcasses was generally applied in all plants. Although most spray-washing procedures were fairly well specified, data concerning the usage and/or pressure of water were not available for some plants, making a general comparison of the way of operation difficult.

The amount of lactic acid (< 5 ppm), unintentionally added to the water of the spray-washer from one plant, has to be considered as to low in order have an inibitory effect on the bacterial growth.

In one plant (5*), carcasses were washed again when leaving the "drag" chiller.

Since tap water was used for washing or spraying of birds, bacteriological specifications of the wash water may be deduced from the data presented elsewhere.

d) Chill water

Chlorination of the chill water was not applied. All measured levels of residual chlorine were below or near to the detection limit.

Throughout the entire experimental period, lowest counts at the exit side of the chilling system for both total and coliform organisms were obtained in the two-unit counter current chiller (plant 1).

Consequently, it can be concluded that addition of crushed ice to the chill water (cf. plants 5 and 5*) is of secondary importance to control the bacteriological contamination, provided the direction and the flow of the water are adequately adjusted. Nevertheless, maintaining the chill water at a low temperature should not be omitted since low water temperature contributed to control coliform organisms at reduced level. Besides, of course it makes chilling more complete.

In water samples collected on both, carcass-entry and -exit side from 3 out of 5 immersion-chilling systems, salmonella organisms were occasionally present. For 2 plants, the same serotypes had also been isolated from the scalding water.

Therefore, as for any system in which a large number of birds comes in contact with the same fluid or working surfaces, a hazard for carry-over of microorganisms, including salmonellae, from one carcass to another may occur.

In some previous experiments, total counts amounting up to averagely 10^3 to 10^5 per ml were usually found. Some authors reported counts up to 10^6 per ml and even higher. High counts were often associated with high water temperatures and/or very low water flows.

With regard to feacal contamination, enterobacteriaceae- and coliform counts ranging between 10^2 to 10^4 per ml chill water were frequently found.
Out of the literature, some evidence is given that high bacterial counts in chill water are mainly due to insufficient water flows. Even when the temperature of the water is maintained close to 1°C, accumulation of psychrotrophic spoilage bacteria in the chilling tank cannot be avoided unless adequate water flow is applied. With reference to this particular aspect of the immersion-chilling process, some evidence was found from literature that, given an adequate water flow, the microorganisms in the chill water should not exceed a level of 10^5 per ml.

The results from the present study show that throughout all immersion chilling systems, total and coliform counts of the chill water never exceeded a 10^4 -range per ml.

At the exit side of all chilling systems, total and coliform counts per milliliter chill water were generally at the 10^3 - and at the 10^2-range, respectively.

E) Bacteriological contamination of carcasses during processing

a) General remark

The site of sampling of carcasses (neck skin) and laboratory procedures (maceration technique) were established in a way that maximal recoveries for total and coliform counts had to be expected.

Compared to other procedures such as rinsing of a whole carcass or swabbing of a definite surface (10 cm^2) of the breast skin, examination of shaked neck skin samples were reported in the literature to yield counts which were respectively 1.0 and 2.5 log higher. For that reason, the results of the present study cannot be compared as such with those obtained by alternative techniques such as swabbing, rinsing or even maceration of skin samples from other regions of the carcasses which are usually found to be less contaminated than the neck skin region.

Some other consequences of the site of sampling and the use of a particular laboratory technique on the evaluation of the impact of some technological procedures during slaughter and further processing stages on surface contamination of poultry carcasses will also be discussed further on.

In order to make at random samplings as much as possible for each plant, identical sampling procedures were carried out on 8 different experimental periods covering 4 days and 2 weeks respectively.

b) Evolution of total and coliform contamination

1. After plucking

Considerable variation in the counts of neck skin samples of birds from different plants was found. However, for most plants the variability between the different experimental periods was also high.

After defeathering, the lowest average counts for both total and coliform organisms were obtained for the plant using the highest water temperature during scalding (plant 2), thus indicating a benificial effect of high-scalding on surface contamination of broiler carcasses.

On the other hand, the very high initial contamination, i.e. log 6.01 to log 6.22 and log 4.96 to log 5.51 for total and coliform counts respectively, measured on the birds from two air-chilling plants

practising low-scalding (plants 3A and 3*A), could not be related directly to inadequate scalding temperatures since water temperature was at the same range as for all other low-scalding procedures.

However, the bacterial load after plucking can be influenced by other factors than scalding, e.g. by the level of contamination of the ingoing birds, the spread of contamination during subsequent defeathering and the introduction of a spray-cleaner after the final plucking stage.

Whereas the contamination of birds before killing and after scalding before entering the plucking machine, was not measured, the effect of both former factors on surface contamination of picked birds could not be evaluated. Nevertheless, from the results for one plant (plant 1) there was some evidence for the spread of coliform organisms during the plucking stage.

Also with regard to the effect of spray-cleaning immediately after plucking, no conclusive results were obtained since comparative evaluation of the counts showed that birds from only two of the four plants where spray-cleaning was used, could be qualified as low contaminated (plants 2 and 4), whereas carcasses from one of these four plants were extremely high contaminated (plant 3A).

2. After evisceration

Whereas for some plants (1, 5, 5*, 3A, 3*A, 5A) the level of contamination during evisceration did not increase to any marked extent, in other plants (2, 4, 1A, 2A, 4A) total and coliform counts were markedly increased after evisceration. In several cases this increase was shown to be significant.

Regarding the control of spread of feacal contamination during evisceration, from the present study it cannot be concluded whether manual or automatical evisceration should be preferred.

On the contrary, it was very striking that increase of surface contamination only occured in those plants where counts prior to evisceration were relatively low, whereas little variation was only found for those plants, showing already high initial levels of contamination. Consequently, some difference in bacteriological standards of birds from different plants were partly equalized during evisceration.

3. After spray-washing

The results from the present study demonstrate that for some plants (4, 4A and 5, 5A) spray-washing significantly decreased both total and coliform counts. Technical data on the equipment indicated that in these plants spray-washing was properly operated. In a few other plants, a marked reduction was obtained for either coliform- (plant 3A) or total counts (plants 1A and 2A). For plant 2A, however, attention should be drawn to the fact that lactic acid had been added to the wash water.

For 3 plants only (2, 3*A and 5*), a consistant beneficial effect of spray-washing on neck skin contamination could not be demonstrated. However, it should be noticed that due to draining of the wash water into the lower parts of the carcasses, microorganisms tend to accumulate in the neck skin region where the samples were being taken. This may explain why in some plants an increase in the neck skin contamination has been observed.

Moreover, previous studies have demonstrated that the removal of bacteria from the skin is highly related to the attachment of the bacteria to the skin. In a series of experiments carried out by Dutch scientists, it was also pointed out that the attachment was not only related to the temperature of the medium and the bacteria species involved but also to the stage at which contamination has been occured, showing that bacteriological contamination which occurs on an early stage in the processing line (e.g. during scaling or plucking) is less easy to remove than when occuring on a further stage (e.g. during evisceration).

Consequently, the evaluation of the effectiveness of the spray-washing procedure not only depends on the type of bacteria and the moment of contamination but also on the analytical method.

From these findings it was suggested that the skin macerating method reveals the build up of microorganisms on the skin throughout the whole slaughter procedure, whereas the results of the rinsing method reflect only the hygienic precautions taken at the end of the line. It also explains why counts determined by the skin macerating method cannot be related to those obtained with alternative methods.

Nevertheless, it could be concluded from this study that spray-washing, when properly used, generally improved the bacteriological standard of the carcasses prior to chilling.

4). After chilling

The remarks concerning the attachment of bacteria to the skin and the consequences of this phenomenon on the use and evaluation of the experimental methods for determination of the counts do also apply to this processing stage.

-Immersion-chilled birds :

Evaluating the results for the coliform contamination, it was shown that coliform counts were significantly reduced after the carcasses had been passed through the immersion-chilling system from 4 out of 5 plants (1, 4, 5 and 5*). The reduction expressed by the decrease in percent of the coliform counts before entering the chiller was most obvious for the plant 1. For that plant, reductions ranging from 75% to 94% were established.

For one plant only (2), although on some experimental periods reductions amounting up to 93% occured, the reduction was not significant when evaluating the results obtained from the whole experiment.

With regard to the total counts, a significant decrease was found on birds from 3 plants (1, 5, and 5*).

For plant 5*, some restrictions should be made regarding the evaluation of the wash-effect on birds in the chiller since for that plant carcasses were sprayed again when leaving the chilling tank. However, the high bacteriological standard of the chill water at the exit side of the tank does not support the assumption that the benificial effect should be attributed mainly to the subsequent spray-washing of the carcasses.

From these findings it can be generally concluded that, although immersion chilling is only conceived to chill carcasses in a very short time, immersion chilling of birds may contribute to the improvement of the hygienic standard of the product.

The experiments also indicated that an adequately used spray-washer, combined with a properly operated immersion-chilling system, do remove a substantial part of the bacteria from the surface of the carcasses.

Although, as already mentioned above, an objective comparison with results from other experiments studying alternative water-chilling procedures cannot be made, it has been demonstrated in the present experiment that satisfactory cleansing of carcasses can be achieved by a combined action of spray-washing and immersion-chilling procedures.

The unfavourable results which were repeatedly obtained for plant 2, were not only related to inadequate operation of the one-unit counter current system but mainly to the ineffectiveness of spray-washing that preceeded the chilling process.

Since very low coefficients of correlation were obtained, there was no statistically proved evidence that decrease, respectively increase, in coliform and total counts was related to the hygienic standard of the eviscerated birds. Therefore, it may be assumed that the hygienic condition of the chilled birds is mainly related to an optimal combination of a number of physical parameters such as residence times of carcasses, waterflow, direction of the flow and temperature of the chill water.

This settlement was also confirmed by the fact that beneficial effects were achieved by different immersion-chilling systems, provided they were properly used. On the contrary, the employment of a well conceived chiller alone does not guarantee an improvement of the hygienic standard of the birds unless the system is also properly operated.

- Air-chilled birds :

In contrast with the immersion-chilled birds, consistent reduction in total and coliform counts was only exceptionally observed during air chilling of birds.

This is not surprising since complementary rinsing of carcasses, which occurs during properly used immersion chilling, was avoided.

Because of the high variability between counts of carcasses from different plants prior to chilling, comparison of counts on carcasses either chilled by air or in water, is irrelevant.

Only the counts from plant 5, 5A were comparable since the results for air-chilled and immersion-chilled birds were obtained on the same batches of birds slaughtered and eviscerated on the same experimental periods. Doing so, total and coliform counts were shown to be generally lower for immersion-chilled than for air-chilled carcasses.

5. After packaging

With only few exceptions (plants 1, 1A and 5A), total and coliform counts showed little further change during the packaging stages. Owing to the short delay which usually occurs between chilling and packaging of the carcasses, perceptible variations in the extent of surface contamination are not to be expected.

Nevertheless, build up of microorganisms at the packaging station and increase of counts in poultry carcasses during weighing operations have been reported. These findings are confirmed by results obtained in one immersion-chilling plant (plant 1) showing a significant increase in total counts at the packaging station. Since an accumulation of unpacked birds did not occur at the packaging station of this plant and carcass temperatures were sufficiently controlled at low level to avoid fast bacterial growth, the increased total counts were probably attributable to improper operation or/and low hygienic standards of the calibration equipment. Although no clear evidence was given, technical specifications on the equipment for weighing and calibration of the carcasses support the latter supposition.

Nevertheless, the increase in bacterial counts was rather small compared to the decrease occuring during spray-washing and chilling. Consequently, as for all other plants, changes occuring at the packaging line did not markedly affect the benificial effect of cleansing by spraying and immersion of the eviscerated carcasses.

Reduction of coliform counts which occured at the packaging from two air-chilling plants (plants 1A and 5A) could not be related to any particular factor.

Athough it has been demonstrated by this study that the hygienic standard of the birds can be influenced by some technological procedures (e.g. evisceration, spraying, chilling and packaging) clear evidence was given that the bacteriological standard of the finished product was highly related to the bacteriological condition of the plucked birds.

These findings are in accordance with the statement of some authors that the bacteriological condition of the finished product will depend upon the control of bacteria at all stages of processing and particularly during scalding and plucking.

Consequently, it may be assumed that the hygienic condition during handling of live birds (e.g. during transport) and during the initial stages of slaughter (e.g. during scalding and plucking) are of prime importance for the bacteriological contamination during further processing. This emphasizes the need for further research with regard to the effect of early stages in the slaughter line upon the bacteriological standard of the final product.

Though standards for frozen broilers were suggested by some authors, counts from this study on the finished products cannot be compared objectively to these standards since different sampling- and/or laboratory techniques were used.

Nevertheless, acceptable bacteriological standards of the product could be achieved for both, air-chilled and immersion-chilled birds.

c) Incidence of salmonella organisms

1. Immersion-chilled birds

In all plants, salmonellae were recovered after plucking of birds at least on one of the eight experimental periods. However, a considerable variability in incidence between the plants (from 1.2% contaminated carcasses for plant 1 to 32.5% for plant 5*, for the experiments considered as a whole) as well as between the respective experimental periods for the separate plants occured (e.g. from 0% to 100% for plant 5*).

A significant increase or decrease in the incidence of salmonella-contaminated carcasses between the consecutive processing stages did not occur.

For one plant only (plant 2), there was a trend showing a consistently increasing number of salmonella-contaminated neck

skin samples.

Whereas one serotype generally predominated for each day of the experiment, additional serotypes were occasionally isolated.

2. Air-chilled birds

As for the plants practising immersion chilling, salmonellae were repeatedly isolated from birds immediately after plucking. The variability in the occurence of these organisms was also high between the plants (from 0% for plant 1A to 2.5% for plant 3*A) and between the consecutive experimental periods for the separate plants (e.g. from 0% to 80% for plants 3*A and 4A). For one of those plants (3*A) the number of salmonella positive samples also obviously increased during subsequent evisceration.

In all other cases no definite variation in the incidence of salmonellae between the consecutive sampling stages could be established.

As for the immersion-chilled birds, one particular serotype was usually predominant for each experimental period and other serotypes were only occasionally identified.

For some plants, either practising immersion chilling or air chilling, one particular serotype was predominant throughout the whole experiment. However, by lack of information regarding the extent of contamination of live birds and serotypes involved, it cannot be concluded whether the high incidence of these serotypes is attributable to infection of the ingoing live birds or to a carry-over from one experimental period to the next, respectively from one day or week to the next.

Over-all conclusions with regard to cross-contamination

With regard to the hazard of cross-contamination during processing of birds, more particularly during immersion chilling, no conclusive results could be obtained from the present study. Even if a marked difference in the number of salmonella-positive carcasses occured between consecutive processing stages, the results from tests employed for measuring cross-contamination by differences in the extent of contamination between two stages of poultry processing, should be interpreted with the utmost care.

In recent experimental work, the repeatability of a presence-absence test was found to be poor since the results are strongly influenced by the uneven distribution of microorganisms amongst birds and different regions from a single carcass as well as by the analytical method employed. This objection certainly applies for salmonellae, for only a very small number of these organisms usually occurs on the skin of poultry carcasses during slaughter and further processing.

Studies carried out by German authors demonstrated that birds initially free from salmonellae, when slaughtered later in the day following a contaminated flock, cross-contamination occured during processing.

However, the results from this study give only irrefutable evidence for cross-contamination during the stages prior to chilling, whilst the conclusion for cross-contamination during immersion chilling was drawn from the evaluation of a presence-absence test on a relatively small number of samples.

Nevertheless, as on many other stages throughout the processing line, a hazard for cross-contamination during immersion chilling cannot be excluded when birds carrying salmonella organisms in the intestine or on the skin, are slaughtered amongst non-contaminated birds. However, the present study demonstrates that with reference to other processing stages, the incidence of salmonella-contaminated carcasses can be sufficiently controlled during immersion chilling, provided the equipment is properly used.

As already suggested by other authors with respect to the hazard for spread of salmonellae, attention should in future also be paid to other processing stages than chilling, more particularly to the defeathering procedures (*).

Whichever technological improvement may be introduced, it is evident that any hazard for salmonella cross-contamination in a poultry slaughter plant can only be effectively excluded by eradication of salmonellae in the live birds. This has been confirmed by the results of the present study showing that, given an absence or a very low occurence of salmonella-contaminated birds at the initial processing stages, salmonellae were

---

(*) With the exception of two Institutes, all participants agreed upon the discussion and scientific interpretation elaborated within the 4 preceeding paragraphs.

also absent or controlled at a very low level during further processing.

F) Physical condition of carcasses during processing

a) Average temperature

In the four immersion-chilling plants (plants 1, 4, 5 and 5*) operating according to good manufacturing practices, carcasses were chilled within about 20 minutes up to less than 1 hour at average temperatures ranging from 7.25 ±0.5°C to 8.93 ±0.7°C. For one plant only (plant 2), using insufficiently cooled chill water, average temperatures up to 11°C were occasionally measured.

Average temperatures of the packaged carcasses generally remained near or below 10°C. Since subsequent to packaging, immersion-chilled birds are immediately being blast-frozen, further bacterial growth until defrosting of the product, is to be neglected.

Consequently, total results showed that, as for air chilling, continuous immersion chilling can provide a decrease in carcass temperature within an acceptable period of time in order to avoid rapid bacterial growth on the surface of the product.

b) Changes in weight during chilling

In contrast with air chilling, resulting in a slight loss of weight (e.g. averagely 0.08 to 0.8% of the eviscerated weight) due to the evaporation of surface moisture, immersion chilling of birds gives rise to an increase in weight of the product.

In these plants, practising immersion-chilling according to good manufacturing practices, total water-uptake during spray-washing and subsequent immersion chilling amounted from 4.1 ±0.9% up to 6.6 ±1.7% of the eviscerated weight.

From these amounts, approximately 1.3 to 1.5% emanated from the spray-washer.

For the immersion-chilling system which was not properly operated (plant 2), the average amount and the standard deviation (S_1) for water-uptake during spray-washing and chilling were increased to 8.9% and 5.6% respectively.

V - FINAL CONCLUSIONS

The present study was entirely carried out in a number of industrial slaughtering plants operating under practical conditions.
Whereas some plants were practising classical air-chilling procedures, delivering broilers for fresh (chilled) trade, other plants practised some types of continuous immersion chilling, yielding birds to be sold in a frozen state.

Considering total results from this study, no evidence has been given that a well operated immersion chilling system has a negative influence on the hygienic standard of the product, compared to air-chilling procedures. On the contrary, an additional washing effect, resulting in a reduction of the bacteriological contamination of the surface occurs during properly operated immersion chilling.

On the other hand, decontamination of birds by passing through an air-chilling system is excluded and therefore may lead to higher counts on the surface of the final product.

Nevertheless, acceptable bacteriological standards of the final product can be achieved with air chilling as well as with immersion chilling, provided the hygienic conditions during slaughter and evisceration are sufficiently proper. In this respect, adequate spray-washing of birds prior to chilling is to be generally recommended.

However, irrespective to the cleaning effect of immersion chilling and/or spray-washing, the bacteriological standard of the final product is highly related to the condition of the birds immediately after plucking. Consequently, it may be assumed that the hygienic condition during handling of the live birds (e.g. during transport) and during the initial stages of slaughter, particularly during scalding and plucking, are of prime importance for the bacteriological contamination during further processing. These findings emphasize the need for more research with regard to the effect of early stages in the slaughter line upon the bacteriological condition of the final product.

With regard to the hazard of cross-contamination during processing, more particularly during immersion chilling, no conlcusive results could be obtained from the present study. However, the results gave no evidence that, compared to other

processing stages, properly operated immersion chilling represents a particular hazard for spread of salmonellae.

Carry-over of micro-organisms from one carcass to another may occur on many stages throughout the processing line where contact, either direct or indirect; between carcasses cannot be avoided. Therefore, attention should be paid to the hazard of cross-contamination with salmonellae throughout the processing line from slaughter up to packaging. Nevertheless, whichever technological improvement may be introduced in the processing line, cross-contamination with salmonellae can be prevented only by eradication of salmonellae in the live birds.

In properly operated immersion-chilling systems (e.g. minimum waterflow of 2.5 1/ carcass and water temperatures controlled near or below +5°C at the exit side of the system), chilling of carcasses at average temperatures below +10°C was achieved within 20 to 60 minutes. Nevertheless, immersion chilling represents only a first stage of chilling since the birds, immediately after packaging, are blast-frozen at temperatures below -30°C.

Total water-uptake during spray-washing and subsequent immersion chilling can also be controlled at a low level.

Since instruments required for continuous survey of chilling procedures are abailable, monitoring of the way of operating is no longer a technical problem. Total cost for installation of suitable equipment amounts up to approximately 10 percent of the total investment required for installation of a counter-current immersion chiller.

Additionally to a compulsary introduction of all required equipment and recording devices in order to ensure permanent monitoring of the immersion-chilling process by an inspector, permanent in-plant and trade control of the bacteriological and physical condition of the product would also protect the consumer against the illicit use of immersion chilling.

On the assumption that immersion chilling of poultry carcasses would be forbidden, it is also to be considered that no adequate alternative water-chilling procedure which can also economically be applied, has been developed until now. In that case, air chilling would remain the sole alternative way of chilling. This technique, however, is actually providing mainly a fresh product as handling and storage of air-chilled poultry for freezing creates some additional problems and also limits the shelf-life.

Consequently, some types of immersion chilling, in combination with a spray-washer prior to chilling, could be retained at this time on the condition, however, that the way of operation meets a series of specifications with regard to the construction of the system, instructions for cleaning and disinfection before start of operation, checking of the water supplies, minimum requirements for overflow and temperature of chill water and the set up of an adequate control system.

The results of the present study have not demonstrated any objection to the use of immersion chilling from the hygienic point of view provided that chilling systems are operated properly. The final decision whether some types of immersion chilling are acceptable or not, should not only be related to the hygienic aspects but also to considerations of an economic nature, such as the uptake of extraneous water, the applicability of alternative chilling procedures and their costs for installation and operating involved.

ANNEX

STUDY FOR THE EVALUATION OF THE HYGIENIC PROBLEMS RELATED TO THE CHILLING OF POULTRY CARCASSES

TABLE 1 : SLAUGHTERING- AND CHILLING PROCEDURES (IMMERSION-CHILLED BIRDS)

	PLANT	1	2	4	5	5*
LIVE BIRDS	Breed	White Plym.Rock	Studler 160	Hypeco	Ross Hybrid	Ross/Hubbard
	Live weight (g)	1500	1350	1300	2000	1500
	Starvation	yes (±20hrs)	yes (12 hrs)	?	yes	yes
	Transport (road)	1 1/2 h	1 hr (50 km)	2 hrs	40/50 km	18 km
	Crates	plastic (REINDERS)	?	plastic (ISRAEL)	metal	metal
	Birds per crate	?	30	16	18	20
	Delay betw. arr. and slaughter	± 1 h	1 - 3 hrs	1 - 5 hrs	± 1h 20 min.	± 1 h
SLAUGHTERING	Capacity/h	4,080	9,500 (2 lines)	3,000 (1st w) 3,200 (2nd w)	2,880	2,500
	Stunning	Water bath (LINDHOLST)	Water bath	Water bath	Water bath (STORK)	Water bath (MEYN)
	Killing	automatically (home made)	automatically (STORK)	automatically	manually	automatically
	Bleeding time (sec.)	153	91	182/171	200	200
SCALDING	Type	STORK	STORK 32D	LINDHOLST		
	Volume of tank	?	12 m^3	9 m^3	length 25 m	length 25 m
	Residence time (sec.)	62	77	170 (1st w) 151 (2nd w)	202	147/165
	Water temp (°C)		en-ex. opposit.	entry exit	en -ex. opposit.	en-ex. opposit.
	Water temp (°C)	61	63.4±0.9 62.4±0.5	1st w 53.7±1.5 59.0±0.1 2nd w 57.0±1.2 61.4±0.6	50.5±0.5 50.5±0.5	52.6±0.5 52.6±0.5
	Water flow (l/carcass)	0.22	?	0.30	0.31	0.36

Contnd. TABLE 1

	PLANT	1	2	4	5	5*
PLUCKING	Type	STORK	STORK S and L	MEYN	GORDON JOHNSON-STEVENS	GORDON JOHNSON-STEVENS
	Number	2	3	1	4	2
		1: rubber finger 2: rubber flails	rotating discs	rotating discs	1, 2 and 3: rotating discs 4: rubber flails	rotating discs
	Residence time (sec./unit)	un.1 16 un.2 17	?	?	un.1 19 un.2 12 un.3 19 un.4 24	un.1 15 un.2 15
	tot.res.time (sec.)	33	28	36 (1st w) 32 (2nd w)	74	30
	Water temp.(°C)	10	16.2 ±4.2	13 - 14	56	?
	Water flow (l/carcass)	un.1 0.53 un.2 0.23	?	?	0.09 (4th un.)	?
SPRAY-CLEANING	Type	2 x 3 nozzles (home made)	2 nozzles	2 x 3 nozzles (LECHLER FUN 12/60)		
	Distance from carcasses	?	10 cm	15 cm	NOT USED	NOT USED
	Water temp.(°C)	27	9.2 ±1.2	12 - 13		
	Residence time (sec.)	4	1	1.8 - 2.0		
	Water flow (l/carcass)	0.4	?	0.15		
EVISCERATION	Cutting of neck skin	mechanically		mechanically	manually	mechanically
	Vent cut	rotary knife (JARVIS)	vent gun	vent gun	knife (man.)	3-stage "MEYN"-full automatic evisceration system, comprising neck breaker, vent cutter, -opener
	Abdom. cut	Scissors (man)	knife (man.)	knife (man.)	knife (man.)	
	Evisceration	mechanically (STORK)	mechanically (STORK)	mechanically (S STEMATE)	manually	
	Removal of heart liver, gizzard..	manually	manually	manually	manually	manually

Contnd. TABLE 1

	PLANT	1	2	4	5	5*
	Veter. inspect.	inspection and palpation of every ingle carcass	supervision by lay-inspectors	inspection and palpation of every single carcass	no veterinary inspection	no veterinary inspection
	Cleaning of carcasses	cleaning after evisceration with water for 13 sec. (water temp. 26°C)	water consumpt. of 0.32l/carcass during evisc. No cleaning after evisc.	3 showers in the evisc. line with a total water flo of 0.41 l/carcass	no cleaning during evisc.	no cleaning during evisc.
SPRAY-WASHING	Neck cutting	STORK	STORK	mechanically	manually	?
	Type of spray-washer	2 sloped tubes with 2x3 nozzles	24 nozzles	24 nozzles 2x6 on each side (LECHLER FUN 12/60)	8 nozzles + rubber flails	18 nozzles
	Distance from carcasses	± 20 cm.	10 cm.	10 -15 cm.	15 cm.	30 cm.
	Water temperature°C	22	10.1 ±0.2	13.5 ±0.4	10.4 ±0.4	9.5 ±0.5
	pressure	3	?	?	1.4	2.1
	flow (l/carc.)	?	?	1.10 (1st w) 0.82 (2nd w)	0.42	0.77
	Residence time (sec.)	7	22	6.6 (1st w) 5.9 (2nd w)	13.6 ±1.6	15
CHILLING	Type	counter-current (LINDHOLST)	± counter-current (STORK)	counter-current (STORK)	through-flow (GORDON JOHNSON-STEVENS)	"drag" chiller (constructed of concrete)
	Number of units	2	1	1	2	1
	Agitation by air	yes	yes	yes	no	yes
	by screw (rpm)	yes	0.8	0.64	1st un.:revolving drum (10rev/m 2nd un.:"spin-flex" paddles (6 rev/m)	no

Contnd. TABLE 1

	PLANT	1	2	4	5	5*
IMMERSION CHILLING	Volume	1st un.: 1.2x8 m 2nd un.: 1.2x16 m	40 m^3	18.5 m^3	1st un.: 4 m^3 2nd un.: 11.2 m^3	45.5 m^3.
	Water temp.(°C) tank water	entry exit 1st: 19 11 2nd: 12 5	entry mid. exit 23.7 13.2 8.4 ± 8.2 ±2.8 ±0.7	entry mid. exit 12.6 7.7 5.1 ±0.9 ±0.3 ±0.4	entry mid. exit 1st un. 11.9 11.9 12.2 ±0.5 ±0.5 ±0.6 2nd un. 0.3 0.4 0.4 ±0.2 ±0.2 ±0.2	entry mid. exit 5.6 0.4 3.5 ±1.0 ±0.1 ±1.3
	input water	1st un.: 9.0 2nd un.: 2.5	5.5 ±0.5	3 - 4	10.0 ±0.4	3.9 ±0.6
	Water flow (l/carcass)	1st un.: 1.5 2nd un.: 1.0	0.28(*) cf. note on p.7 of the report	1.76 (1st w) 1.91 (2nd w)	1st un.: 4.89 2nd un.: 1.24	3.12
	Ice (kg/carcass)	not used	not used	not used	1.9	0.4
	Total residence time (min.)	46.3 ±5.0 (1st day) 55.4 ±2.2 (2nd d.) 78.5 ±3.5 (3th d.) 91.8 ±2.6 (4th d.)	30.9 ±1.7	31.1 ±4.4	18.0 ±2.6	53.8 ±3.0
POST TREATMENT	Carcass position	hanging on one leg	hanging on one leg	hanging on one leg	hanging on one leg	hanging on one wing
	Dripping time (sec.)	323	20 - 30	375	330	403
	Addition of giblets	yes (plastic bags)	yes	yes (paper bags)	yes	yes
	Weighing	semi-automatically (MOBA)	automatically (MOBA)	automatically (MOBA)	manually	manually
	Packaging	manually (use of bagging cone)	manually (use of bagging cone)	manually (use og bagging cone)	manually	manually

TABLE 2: SLAUGHTERING - AND CHILLING PROCEDURES (AIR-CHILLED BIRDS)

	PLANT	1A	2A	3A	3*A	4A	5A
LIVE BIRDS	Breed	Plymouth Rock/ Cornish	Hubbard (yellow/white)	Cobb (1st w) Hybro/mixed	Mixed (broilers)	Hypeco	Ross
	Live weight (g)	1300	1700	1700	1400 - 2000	1500 - 1600	2000
	Starvation	yes (8-10 hrs)	yes (12 hrs)	yes (12 hrs)	yes (18-24 hrs)	yes	yes
	Transport (road)	2hrs	40 km	7 - 60 km 20 - 80 min.	75 - 125 km 2 - 7 hrs	1 - 2 hrs	40 - 50 km
	crates	plastic (REINDERS)	plastic	plastic	plastic	plastic (REINDERS)	metal
	Birds/crate	20 - 22	10 - 18	10 - 12	10 - 12	16	18
	Delay betw. arr. and slaughter	± 1h	1 - 3 hrs	1.20-3.45 hrs	4 - 7 hrs	1 - 2.5 hrs	1 hr 20 min.
SLAUGHTERING	Capacity/h	2,040	3,100	5,400	2,875	7,000 (2 evisc. lines)	2,880
	Stunning	Water bath (LINDHOLST)	Water bath	Water bath	Water bath	Water bath	Water bath (STORK)
	Killing	manually	automatically (LINCO)	automatically	manually	automatically	manually
	Bleeding time (sec.)	92	138	100	132	127	200
SCALDING	Type	LINDHOLST	VIERIC	?	?	GORDON-JOHNSON	?
	Volume of tank	8.7 m^3	15 m^3	6 m^3	5 m^3	13 m^3	length 25 m
	Water temp.(°C)	50.7 ±0.2	52.2 ±0.5	51.1 ±0.5	51.2±0.3 (entry) 51.9±0.1 (exit)	51.1±0.3(entry) 51.6±0.3(exit)	50.5 ±0.5 (entry-exit)
	flow (l/carcass)	0.35	0.32	?	?	0.30	0.31
	Residence time (sec.)	125 (1st w) 146 (2nd w)	134	185	90	185	202

Contnd. TABLE 2

	PLANT	1A	2A	3A	3*A	4A	5A
PLUCKING	Type	STORK (1) LINDHOLST (2,3)	GORDON JOHNSON -ORTI	MEYN JM 64		GORDON JOHNSON	GORDON JOHNSON-STEVENS
	Number	3	3	2	2	4	4
		1: rub. fingers 2: rub. flails 3: rub. fingers	rotating disces	rotating disces	1: rub. fingers 2: rot. disces	1, 2 and 3: rot. disces 4: washer fin.	1, 2 and 3: rot. disces 4: rub. flails
	Residence time (sec./unit)	un.1 un.2 un.3 20 17 11	?	un.1 un.2 18 11	?	?	un.1 2 3 4 19 12 19 24
	tot.res.time (sec.)	48	64	29	31	43	74
	Water temp. (°C)	un.1 un.2 un.3 25.2 9.3 9.3 ±1.2 ±0.2 ±0.2	37.2 ±4.9	34	26.5 ±1.7	57 - 58	56
	flow (l/carcass)	0.7 0.4 0.2	?	?	?	?	0.09 (4th un.)
SPRAY-CLEANING	Type	NOT USED	NOT USED	Singeing 3 sec. 6 nozzles	Singeing 2 sec. NOT USED	NOT USED	NOT USED
	Distance from carcasses			50 cm			
	Water temp.(°C)			16			
	pressure			0.5 kg/cm^2			
	flow (l/carcass)			0.45			
	Resid.time(sec.)			6			
EVISCERATION	Cutting of neck skin	manually	mechanically	mechanically	mechanically	mechanically	manually
	Vent cut	rotary knife (LINDHOLST)	vent gun	vent gun	vent gun	vent gun	knife (man.)
	Abdom. cut	scissors (man.)	knife (man.)	knife (man.)	scissors(man.)	knife (man.)	knife (man.)

Contnd. TABLE 2

		1A	2A	3A	3*A	4A	5A
EVISCERATION	Evisceration	manually	mechanically (LINCO)	mechanically (STORK)	mechanically (STORK)	mechanically (STORK P40)	manually
	Removal of heart liver, gizzard.	manually	manually	manually	manually	manually	manually
	Veter. inspect.	inspection and palpation of every single carcass	supervision by lay-inspectors	visual inspection (seldom performed)	systematically performed by a lay-inspector	inspection and palpation of every single carcass	no veterin. inspect. system
	Cleaning of carcasses	cleaning after evisc. with water for 1.5-2 sec.-, 29°C flow:0.24 l/car.		amount of water for carcass cleaning during evc. not determinable	no water available for carcass clean. during evisc.	1 shower/line flow: 0.15 l/carcass	no spray-wash during evisc.
	Neck cutting	manually (scissors)	mechanically (GORDON JOHNSON)	mechanically	mechanically	mechanically (STORK)	manually
SPRAY-WASHING	Type	hand sprayer	4 nozzles + rubber flails	24 nozzles	12 nozzles	24 nozzles 2x6 on each side (LECHLER FUN12/60)	8 nozzles (rubber flails)
	Distance from carcasses(cm.)	?	20	20	20	10 - 15	15
	Water temp.(°C)	26.8 ±0.7	36.5 ±5.2	16	14	18.4 ±1.3	10.4 ±0.4
	pressure (kg/cm^2)	3	2.5 (*)addition of lactic acid during 1st w<5ppm	2.5	?	?	1.4
	flow (l/carcass)	0.3		1.1	?	1.21	0.42
	Residence time (sec.)	1.5 - 2.0	15	13	15	7.9	13.6 ±1.6
CHILLING	Type	Home made tunnel	Hot air tunnel (60°C) Chilling room (LOIRE-MATAL-SABROE)	tunnel	tunnel	DRY O'MATIC-tunnel	tunnel (SOUTHERN - REDFERN LTD.)
	Number of units	1	1	3	1	1	1

Contnd. TABLE 2

	PLANT	1A	2A	3A	3*A	4A	5A
AIR-CHILLING	Air temp. (°C)	+5 (entry) -1 (exit)	+5 (evac. air) ±0 - +2 (incoming air)	1st un. +24 (evac.air) +20 (inc. air) 2nd un. +7 (evac.air) +8 (inc.air) 3th un. -1 (evac.air) ±0 (inc.air)	+6 to 7 (ent.) ±0 to 1 (exit)	+0.6±0.6 (ent) +3.7±0.5 -3.6±0.3 (ex) -3.1±0.6	+16 (entry) + 3 (exit)
	Air velocity (m/sec.)	2	3.76 (evac.) 5.65 (incom.)	7 (all units)	not recorded	1	3 - 5
	Residence time (min.)	22	360	un.1: 22 un.2: 34 un.3: 35	123.2 ±9.2	57	112.8 ±17.7
	Carcass position	hanging on one leg (on the line)	stacked in trays after semi-automatical weighing	supported by a framework, introduced in the abdom. cavity	hanging on racks by a wing (15 carcasses/rack)	hanging by the legs on one row of the system (16 carcasses/row; tot.number of rows: 220)	hanging by the legs on appropriate hooks
POST TREATMENT	Addition of giblets	yes (plastic bag)	?	No	No	?	yes
	Weighing	manually	manually	manually	semi-automatically	automatically	manually
	Packaging type	manually separate trays +plast. wrap	manually separate trays +plast. wrap	manually 10 unwrapped carcasses in paper-coated wooden crates	manually 8-10 unwrapped carcasses in polystyrene boxes	manually ?	manually separate trays +plast. wrap
	Time between chilling and packaging	± 15 min.	30 min. (room temp.: +10°C)	2 - 5 min.	2 - 5 min.	4 min.40 sec (*) slightly crust freezing neck skin	?

Site	Number of samples	1st week		2nd week	
		1st day	2nd day	1st day	2nd day
Picker	4	4*	3* 70	3* 50	1* 80 100 90
Shackles slaughter line	2	2*	2*	2*	2*
Conveyor to evisceration line	6	6*	6*	4* 100 100	4* 95 100
Table	2	2*	2*	2*	1* 80
Containers	4	4*	2* 20 15	4*	3* 35
Shackles evisceration line	4	4*	3* 90	3* 100	3* 85
Scales	4	1* 100 100 100	18 90 100 100	3* 100	1* 42 48 95
Packing shelves	9	5* 30 70 70 80	1 5 12 15 15 20 35 50 70	3* 20 90 100 100 100 100	4 33 40 60 65 75 85 95 100
Packing tables	2	1* 60	25 50	80 100	6 100

TABLE 3 : Microbiological flow sheet analysis of equipment in plant 1A Techniques and evaluation of the results cf. report, page 10.

Note: A number followed by an asterix indicates that the contact plates from that particular equipment indicated by the number all had more than 100 colonies. An unaccompanied number gives the number of colonies per plate.

Site	Number of samples	1st week		2nd week	
		1st day	2nd day	1st day	2nd day
Picker	5	5*	2*	2*	1*
			3	50	50
			15	100	60
			90	100	100
					100
Shackles slaughter line	1	1*	1*	1*	0
Conveyor to evisceration line	6	5*	2*	13	3*
		90	10	30	50
			60	50	90
			70	60	100
			100	80	
				80	
Containers	2	10	1	1*	0
		65	40	30	20
Shackles evisceration line	2	12	0	2*	1*
		20	10		10
Eviscerator	2	2*	2*	2*	2*
				100	
Head puller	2	2*	100	20	1*
			100	100	80
Conveyor to chiller	3	50	0	0	2*
		80	0	20	10
		70	11	90	
Chiller tanks	4	10	0	0	0
		10	0	0	10
		30	0	3	28
		60	0	20	40
Conveyor between chiller tanks	1	10	3	5	15
Scales	3	10	30	6	10
		19	60	10	10
		20	90	40	50
Packing tables	5	30	0	0	0
		45	0	0	0
		90	1	0	2
		98	2	0	8
		100	30	30	10

TABLE 4 : Microbiological flow sheet analysis of equipment in plant 1
Techniques and evaluation of the results cf. report page 10.

Note: A number followed by an asterix indicates that the contact plates from that particular equipment indicated by the number all had more than 100 colonies. An unaccompanied number gives the number of colonies per plate.

Plant	Site	Number of samples	1st week		2nd week	
			1st day	2nd day	1st day	2nd day
2A	Picker	1	5	7	6	7
	Head puller	1	6	7	7	7
	Hock cutter	1	4	4	1	7
	Eviscerator	1	5	1	6	6
	Neck cutter	1	6	3	7	5
	Conveyor to evisceration line	1	3	7	5	5
	Packing shelves	1	3	1	4	5
	Refrigerating room	1	1	6	5	6
2	Picker	1	3	4	5	6
	Head puller	1	2	3	6	5
	Hock cutter	1	6	3	5	3
	Eviscerator	1	2	3	6	2
	Neck cutter	1	4	4	4	4
	Conveyor to evisceration line	1	5	5	3	3
	Shackles dripping line	1	6	4	3	3
	Conveyor chiller	1	4	4	5	6
	Chiller tank (wall)	1	4	5	5	5
	Screw of chiller	1	6	2	6	6
	Packing shelves	1	3	7	3	5
	Bagging cone	1	5	5	5	5

TABLE 5 : Microbiological flow sheet analysis of equipment in plants 2 and 2A. Level of contamination is presented by the code number. Techniques and evaluation of the results cf. report page 10.

Site	Number of samples	1st week		2nd week	
		1st day	2nd day	1st day	2nd day
1st picker (fingers)	1	39	0	12	> 50
2nd picker (fingers)	1	> 50	> 50	10	> 50
Head puller	1	25	> 50	6	10
Hock cutter	1	12	5	> 50	6
Conveyor belt (sl.-ev.)	1	0	0	1	0
Neck puller	1	24	> 50	10	> 50
Neck skin cutter	1	6	40	5	> 50
Eviscerator	1	> 50	15	1	2
Conveyor belt (incosc.)	1	0	0	12	1
Racks	1	28	5	40	> 50
Refr. tunnel walls	1	45	1	2	1
Scissors	1	10	17	4	4
Knives	1	12	10	8	1
Collectors	1	4	16	1	2

TABLE 6: Microbiological flow sheet analysis of equipment in plant 3A. Level of contamination is presented by the number of colonies per cm^2 on the surface of contact plates.

Techniques and evaluation of the results cf. page 10 table 2 of the report.

Site	Number of samples	1st week		2nd week	
		1st day	2nd day	1st day	2nd day
1st picker (fingers)	1	>50	>50	>50	>50
2nd picker (fingers)	1	>50	>50	34	>50
Head puller	1	>50	>50	>50	>50
Hock cutter	1	>50	>50	>50	>50
Conveyor belt (sl.-ev.)	1	>50	>50	>50	>50
Neck puller	1	>50	>50	>50	>50
Neck skin cutter	1	>50	>50	>50	>50
Eviscerator	1	27	>50	4	5
Conveyor belt (incosc.)	1	>50	>50	>50	>50
Hangers (individual)	1	>50	>50	>50	>50
Refr. tunnel walls	1	>50	43	35	>50
Racks	1	>50	>50	>50	>50
Scales	1	15	>50	3	>50
Collectors	1	1	2	4	4

TABLE 7: Microbiological flow sheet analysis of equipment in plant 3*A. Level of contamination is presented by the number of colonies per cm^2 on the surface of contact plates.

Techniques and evaluation of the results cf. page 10 table 2 of the report.

Site	Number of samples	1st week		2nd week	
		1st day	2nd day	1st day	2nd day
1st picker	1	4	4	4	4
2nd picker	1	4	-	4	4
Picker (plastic flap)	1	4	4	4	4
Shackle slaught. line	1	4	4	4	4
Scalding tank (wall)	1	4	4	4	4
Head puller	1	4	4	4	4
Hock cutter	1	4	4	4	4
Eviscerator (blade)	1	4	4	4	4
Eviscerator (spoon)	1	4	4	4	4
Eviscerator (blade)	1	4	4	4	4
Eviscerator (spoon)	1	4	4	4	4
Shackles evisc. line	1	-	4	4	4
Neck puller	1	4	4	4	4
Hooks Chilling tunnel	1	4	-	-	-
Hooks Chilling tunnel	1	4	-	4	1
Contamination flap	1	-	-	-	4
Shackles dripping line	1	3	3	0	0
Scales (Moba)	1	4	4	2	4
Packing table (Moba)	1	2	2	3	2
Plastic container (Moba)	1	2	0	3	3

TABLE 8 : Microbiological flow sheet analysis of equipment in plant 4A. Level of contamination is presented by the code number. Techniques and evaluation of the results cf.page 10 table 2 of the report.

Site	Number of samples	1st week		2nd week	
		1st day	2nd day	1st day	2nd day
1st picker	1	4	4	4	4
2nd picker	1	4	4	4	4
Hock cutter 1	1	4	4	4	4
Hock cutter 2	1	4	4	4	4
Container	1	4	4	3	4
Head puller	1	2	4	4	4
Table	1	4	4	4	4
Eviscerator 1	1	4	4	4	4
Eviscerator 2	1	4	4	4	4
Eviscerator 3	1	4	4	4	4
Shackles evisc. line	1	4	4	4	4
Neck puller	1	4	4	4	2
Table lung aspirator	1	4	4	4	2
Conveyor to aspirator	1	4	4	4	0
Chiller wall (entry)	1	4	4	4	2
Chiller screw (entry)	1	4	4	2	0
Chiller wall (exit)	1	4	4	4	4
Chiller screw (exit)	1	4	4	3	1
Conveying trough after chiller	1	4	4	4	4
Buffer tank after chil.	1	4	4	4	3
Shackles dripping line	1	4	4	4	4
Hooks (Moba)	1	4	3	2	4
Buffer tank (Moba)	1	4	4	4	4
(Moba)	1	4	4	4	4

TABLE 9 : Microbiological flow sheet analysis of equipment in plant 4. Level of contamination is presented by the code number. Techniques and evaluation of the results cf. report page 10.

Site	Number of samples	1st week		2nd week	
		1st day	2nd day	1st day	2nd day
1st picker	1	++	2	2	0
2nd picker	1	+++	+++	+	0
3th picker	1	+	1	0	26
4th picker	1	11	0	++	++
Neck cutter	1	0	0	0	0
Hock cutter	1	0	0	0	0
Conveyor to evisc. line	1	1	1	0	0
	1	1	0	0	0
Evisceration equipment	1	0	0	0	0
	1	0	0	0	0
	1	0	0	0	0
	1	0	2	0	0
Head puller	1	0	0	0	0
1st water chiller (wall)	2	0	0	0	0
" " " (paddle)	2	0	0	0	0
2nd water chiller (wall)	2	0	0	0	0
" " " (paddle)	1	0	0	0	++
	1	3	0	0	0
Conveyor betw. chiller	1	0	0	0	0
	1	0	1	1	0
Conveyor 2nd chiller	1	0	0	0	+
Drip line shackles	1	16	0	0	0
	1	16	0	1	0
	1	1	0	0	0
	1	4	0	2	0
Packing line scales	1	0	0	0	0
Packing line conveyor	1	0	0	0	0
Bagging cone	1	0	0	0	0
Air chiller select.table	1	0	0	0	0
Air chiller grad. tray	1	0	0	0	0
Air chiller load.trough	1	1	0	0	0
Air chiller hanging bar	4	0	0	0	0

contd.

Air chiller disch.trough	1	0	0	0	0
Air chiller packing line conveyor	1	0	0	1	0
Air chiller packing scale	1	0	0	0	0

TABLE 10: Microbiological flow sheet analysis of equipment in plant 5, 5A.

Site	Number of samples	1st week		2nd week	
		1st day	2nd day	1st day	2nd day
1st picker	1	+++	2	0	+++
2nd picker	1	8	11	1	98
Head puller	1	1	+	1	0
Hock cutter	1	+++	14	++	8
Chute to evisc. line	1	0	+	0	0
	1	0	66	0	0
Automatic eviscerator	1	24	5	3	+
	1	1	3	7	0
	1	21	0	0	0
	1	0	1	0	41
	1	++	91	0	0
	1	0	80	0	0
Side of chiller	1	1	+	0	33
	1	0	28	66	1
Chiller bar	1	0	0	6	0
	1	1	6	0	0
Orifice air inlet chill.	1	0	++	++	50
Chiller disch. trough	1	0	0	0	0
Drip line shackles	1	15	0	1	0
	1	1	24	0	0
	1	0	5	0	0
	1	5	0	0	0
Packing line scales	1	0	7	0	0
Packing line conveyor	1	0	0	0	0
	1	0	0	0	0

TABLE 11 : Microbiological flow sheet analysis of equipment in plant 5*. Level of contamination is presented by the number of colonies per plate.(
Techniques and evaluation of the results for plants 5, 5A and 5* cf. report page 11.

Plant	Day	Total Count (in 1 ml)		Coliform Count (in 100 ml)	Total Residual Cl_2 (ppm)
1	1	10		2	no data available
	2	40		0	" " "
	3	70		0	" " "
	4	20		0	" " "
		20-22°C/48h	37°C/24h		
2	1	600	12	0	no data available
	2	innumerable	350	innumerable	" " "
	3	innumerable	0	0	" " "
	4	32	2	0	" " "
4	1	<100		<100	<0.01
	2	31.000		<100	<0.01
	3	<100		<100	not measurable
	4	<100		<100	neg.
		20°C/72h	37°C/24h		
5	1	<0.5	<0.5	0	0.1
	2	<0.5	<0.5	0	<0.1
	3	130	<0.5	0	0.1
	4	10	<0.5	0	<0.1
		20°C/72h	37°C/24h		
5*	1	390	<0.5	0	<0.1
	2	340	<0.5	0	<0.1
	3	29	<0.5	0	<0.1
	4	85	<0.5	0	<0.1

TABLE 12 : Bacteriological and chemical characteristics of the tap water used in the IMMERSION-CHILLING plants.
(Coliform counts in plant 4 were determined in 1 ml tap water)

Plant	Day	Total Count (in 1 ml)		Coliform Count (in 100ml)	Total Residual Cl_2 (ppm)
1A	1	<10		0	not detectable
	2	<10		0	" "
	3	<10		0	" "
	4	<10		0	" "
		20-22°C/48h	37°C/24h		
2A	1	72	6	0	not measured
	2	1854	201	0	not detectable
	3	416	246	62	<0.1
	4	not determined		not determined	not measured
3A	1	5		2	not detectable
	2	2		0	" "
	3	2		2	" "
	4	1		0	" "
3*A	1	0		0	not detectable
	2	0		0	" "
	3	0		0	" "
	4	0		0	" "
4A	1	190		<100	<0.01
	2	<100 to 400		<100	<0.01
	3	200		<100	<0.01
	4	<100		<100	<0.01
		20°C/72h	37°C/24h		
5A	1	<0.5	<0.5	0	0.1
	2	<0.5	<0.5	0	<0.1
	3	<0.5	<0.5	0	0.1
	4	<0.5	<0.5	0	<0.1

TABLE 13 : Bacteriological and chemical characteristics of the tap water used in the AIR-CHILLING plants.
(Coliform counts in plant 4 were determined in 1ml tap water).

	PLANT	ENTRY-EXIT SIDE OF SCALDING TANK		OPPOSITE SIDE OF SCALDING TANK	
		Total Count / ml	Coliform Count / ml	Total Count / ml	Coliform Count / ml
IMMERSION CHILLING PLANTS	1	3.37 ±0.41	<1.00	3.29 ±0.39	<1.00
	2	2.86 ±1.04	0.91 ±2.03	2.86 ±1.04	not examined
	4	4.64 ±0.55	2.42 ±1.30	3.90 ±0.41	0.40 ±0.76
	5	5.23 ±0.21	3.15 ±0.58	4.87 ±0.40	2.46 ±0.33
	5*	5.00 ±0.35	2.88 ±0.38	5.17 ±0.11	2.88 ±0.25
AIR CHILLING PLANTS	1A	5.92 ±0.31	3.37 ±0.33	5.91 ±0.51	3.03 ±0.47
	2A	3.87 ±0.74	1.47 ±0.61	3.76 ±0.65	1.72 ±1.12
	3A	5.47 ±0.52	3.55 ±0.47	not examined	not examined
	3*A	6.14 ±0.49	4.49 ±0.26	6.30 ±0.47	3.95 ±0.48
	4A	5.99 ±0.22	4.71 ±0.41	5.83 ±0.24	4.62 ±0.39
	5A	5.23 ±0.21	3.15 ±0.58	4.87 ±0.40	2.46 ±0.33

TABLE 14 : Bacteriological contamination of the scalding water, presented by the geometric means (log $\pm S_1$). during the consecutive experimental periods (n = 8).

Remark: Except for plant 3*A, birds entered and left the scalding tank at the same side.

	PLANT	ENTRY-EXIT SIDE		OPPOSITE SIDE	
		Salmonella present in		Salmonella present in	
		1 ml	100 ml	1 ml	100 ml
LOW SCALDING (air chilling)	1A	n.d.	n.d.	n.d.	n.d.
	2A	n.d.	5 (S.St.Paul)	n.d.	n.d.
	3A	n.d.	n.d.	NOT EXAMINED	
	3*A	n.d.	n.d.	n.d.	n.d.
	4A	n.d.	5 (S.agona) 6 (S.schwarzen-grund)	n.d.	1 (S.heidelberg) 2 (S.oranienberg) 6 (S.infantis)
	5A	n.d.	n.d.	n.d.	n.d.
HIGH SCALDING (*) (immersion chilling)	1	n.d.	n.d.	n.d.	n.d.
	2	4 (S.St.Paul)	4 (S.St.Paul)	NOT EXAMINED	
	4	n.d.	1 (S.heidelberg)	n.d.	n.d.
	5	n.d.	n.d.	n.d.	n.d.
	5*	n.d.	n.d.	n.d.	n.d.

TABLE 15: Presence of salmonella in the scalding water (1 and 100 ml samples) during the 8 consecutive experimental periods.
Salmonella-positive samples are indicated by the reference number, corresponding to the respective experimental periods.

n.d. = not detectable

(*) = Except for plant 5 and 5*

Remark: Except for plant 3*A, birds entered and left the scalding tank at the same side.

PLANT	FIRST UNIT				SECOND UNIT			
	ENTRY SIDE		EXIT SIDE		ENTRY SIDE		EXIT SIDE	
	Total Count/ml	Coliform Count/ml	Total Count/ml	Coliform Count/ml	Total Count/ml	Coliform Count/ml	Total Count/ml	Coliform Count/ml
1	4.56 ±0.32	4.03 ±0.12	not examined	not examined	not examined	not examined	2.92 ±0.20	2.10 ±0.43
2	4.30 ±0.52	3.51 ±1.30	3.61 ±0.37	1.58 ±0.30		NOT	USED	
4	4.18 ±0.39	3.64 ±0.38	3.70 ±0.53	2.57 ±0.22		NOT	USED	
5	3.34 ±0.24	2.72 ±0.26	3.46 ±0.13	2.67 ±0.32	3.51 ±0.21	2.74 ±0.27	3.53 ±0.23	2.76 ±0.16
5*	3.41 ±0.23	2.65 ±0.17	3.62 ±0.26	2.91 ±0.37		NOT	USED	

TABLE 16 : Bacteriological contamination of the chilling water, presented by the geometric means (log $\pm S_1$) during the consecutive experimental periods (n = 8).

	FIRST TANK				SECOND TANK			
	ENTRY		EXIT		ENTRY		EXIT	
	Salmonella present in		Salmonella present in		Salmonella present in			
PLANT	1 ml	100 ml	1 ml	100 ml	1 ml	100 ml	1 ml	100 ml
1	n.d.	4 (S.agona)	NOT EXAMINED		NOT EXAMINED		n.d.	3(S.agona) 4(S.agona)
2	5 (S.St.Paul)	1 (S.St.Paul) 3 (S.St.Paul) 5 (S.St.Paul)	5 (S.St.Paul)	1 (S.St.Paul) 5 (S.St.Paul)	NOT APPLIED			
4	n.d.	1 (S.heidelberg) 4 (S.heidelberg)	n.d.	1 (S.heidelberg)	NOT APPLIED			
5	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
5*	n.d.	n.d.	n.d.	n.d.	NOT APPLIED			

TABLE 17: Presence of salmonella in the chilling water (1 and 100 ml samples) during the 8 consecutive experimental periods.
Salmonella-positive samples are indicated by the reference number, corresponding to the respective experimental periods.

n.d. = not detectable

Plant	Exper. period	Sampling stage 1	2	3	4	5
1	3	-	-	-	agona	-
	4	agona	-	-		-
2	1	st.paul	-	st.paul	st.paul	st.paul
	2	-	-	-	-	st.paul (1x) typhimurium (1x
	3	-	-	st.paul	-	st.paul
	4	-	-	-	-	st.paul
	5	st.paul	st.paul(5x) bareilly(4x)	-	st.paul(5x) bareilly(1x)	st.paul(5x) bareilly(1x)
	6	st.paul	-	st.paul	st.paul(8x) bareilly(2x)	st.paul(6x) bareilly(2x)
	7	-	-	-	-	st.paul
	8	-	-	-	-	st.paul
4	3	-	heidelberg	heidelberg	heidelberg	-
	4	-	-	-	-	heidelberg
	7	-	infantis	infantis	-	infantis
	8	infantis	infantis(1x) brandenburg(1x)	agona	-	infantis
5	3	typhimurium	typhimurium	typhimurium	typhimurium	typhimurium
	4	typhimurium	typhimurium	-	-	-
	6	-	-	typhimurium	-	-
	8	indiana	4.12.d	-	-	indiana
5*	2	-	-	livingstone	-	-
	4	-	-	-	bredeney	bredeney
	5	typhimurium	typhimurium	typhimurium	typhimurium	typhimurium
	6	typhimurium	typhimurium	typhimurium	typhimurium	typhimurium
	7	livingstone	-	-	-	typhimurium
	8	livingstone	-	-	-	-

TABLE 18: Survey of salmonella serotypes isolated from birds during the consecutive processing stages. IMMERSION-CHILLING PLANTS

Only when isolating more than one serotype, the number of isolations for the different serotypes is mentioned between brackets.

Plant	Exper. period	Sampling stage 1	2	3	4	5
2A	1	infantis	infantis	infantis	infantis	infantis
	2	infantis	infantis(7x) st.paul(2x)	infantis	infantis	infantis
	6	-	-	-	st.paul	-
	7	st.paul	-	-	-	-
	8	-	-	st.paul	st.paul	-
3A	1	infantis	-	-	-	not examined
	2	-	anatum (1x) infantis (1x)	anatum	-	not examined
	7	infantis	infantis	-	-	not examined
	8	typhimurium	-	-	-	not examined
3*A	1	lille	lille(2x) st.paul (1x)	-	-	not examined
	3	-	st.paul	-	-	not examined
	4	-	anatum	anatum(6x) livingstone(1x)	anatum	not examined
	5	enteritidis	enteritidis(6) agona(2x) anatum (1x) tennessee (1x)	enteritidis	-	not examined
	6	livingstone(2x) anatum (1x) agona (1x)	agona	agona	agona	not examined
	7	enteritidis(1x) agona (1x) bredeney (1x) schwarzengrund (1x)	anatum (1x) enteritidis(1)	enteritidis(3x) agona (1x) haifa (1x)	-	not examined
	8	agona (1x) haifa (1x)	agona(2x) haifa (1x) enteritidis(1)	agona(2x) haifa (1x) enteritidis (1x)	-	not examined
4A	1	heidelberg	heidelberg	-	-	heidelberg
	2	senftenberg	senftenberg	heidelberg	-	senftenberg
	3	infantis	infantis	infantis	infantis (2x) group E_1 (1x)	infantis
	4	infantis(7x) eimsbüttel (1x) senftenberg (1x)	infantis	infantis	infantis (1x)	infantis (1x) group C_1 (1x) rough (1x)
	5	agona	agona	agona	-	-
	6	-	infantis	-	agona	agona
5A	1	-	-	-	typhimurium	
	3	typhimurium	typhimurium	typhimurium	typhimurium	typhimurium
	4	typhimurium	typhimurium	-	-	typhimurium
	5	-	-	-	typhimurium	-
	6	-	-	typhimurium	-	-
	8	indiana	4.12.d	-	-	-

TABLE 19 : Survey of salmonella serotypes isolated from birds during the consecutive processing stages. AIR-CHILLING PLANTS.

Only when isolating more than one serotype, the number of isolations for the different serotypes is mentioned between brackets

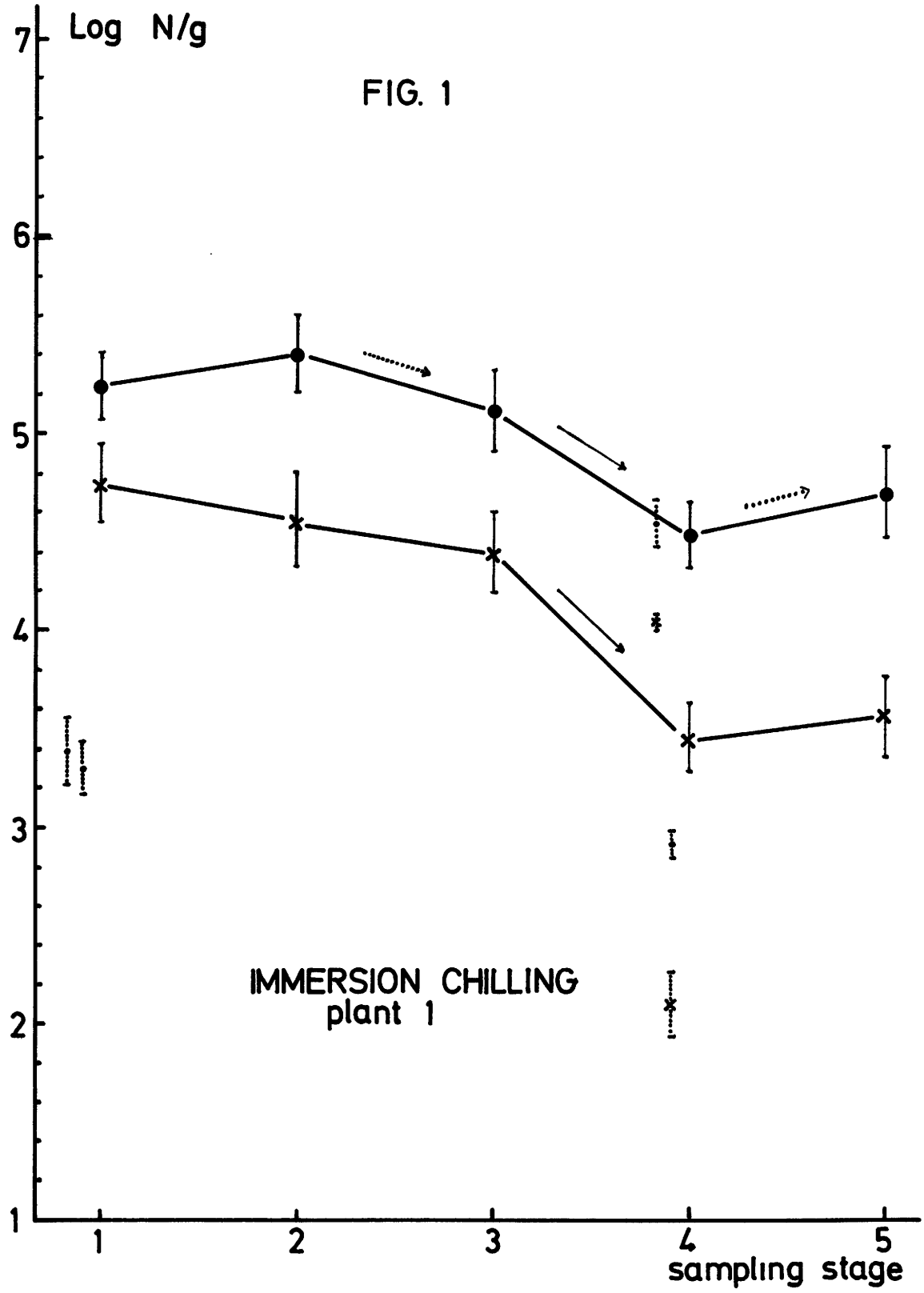

FIG. 1 : Geometric means $\pm$SEM$_1$ of bacterial counts at different stages of processing.

Significant increase or decrease at

1% level ——→
5% level - - →
10% level .....→

●——● | total count / g — neck skin
X——X | coliforms / g — neck skin

. . ● . . | total count / ml — scalding and chilling water
. . X . . | coliforms / ml — scalding and chilling water

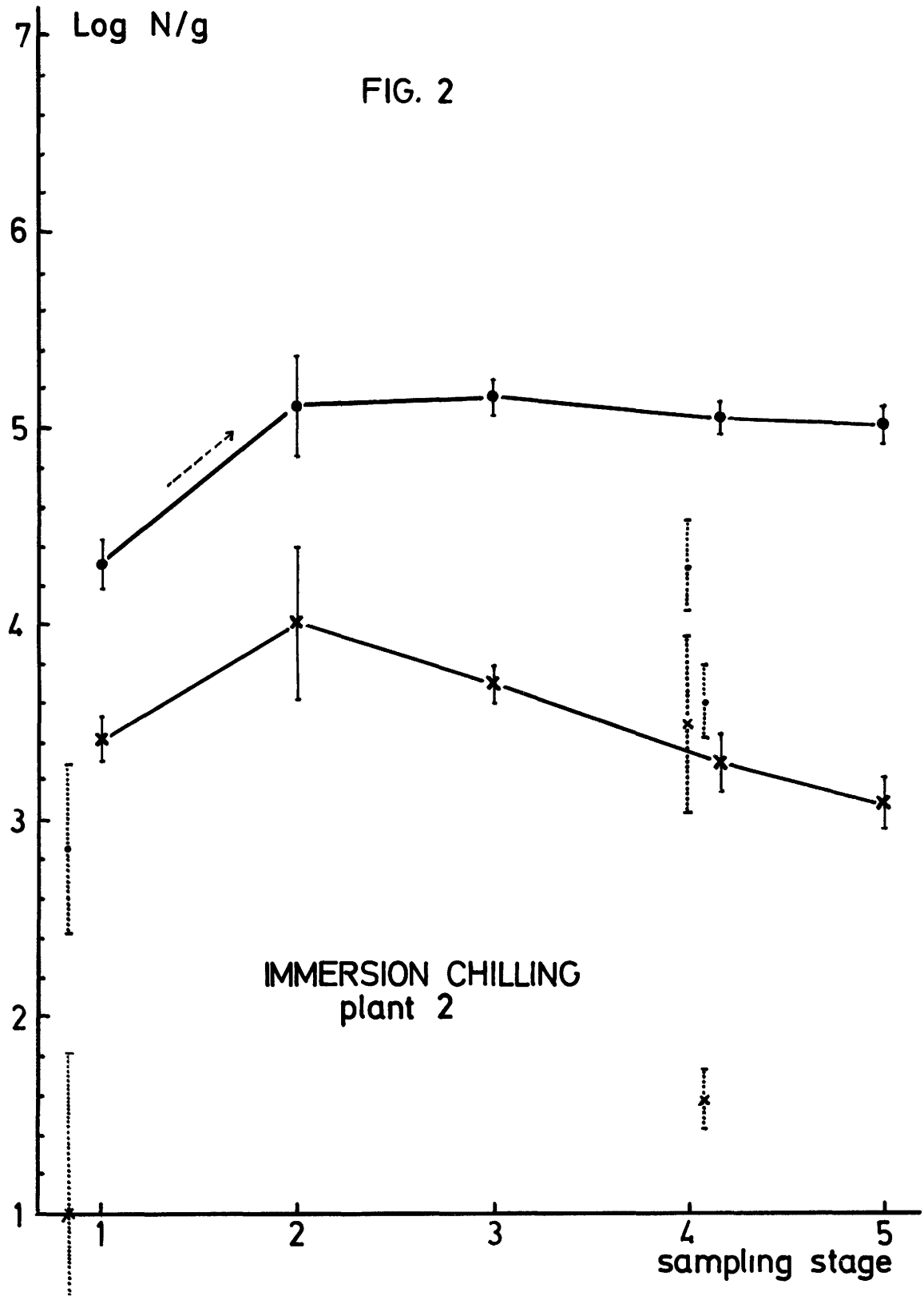

FIG. 2 : Geometric means $\pm$SEM$_1$ of bacterial counts at different stages of processing.

●——● | total count/g
X——X | coliforms/g
neck skin

. . ● . . | total count/ml
. . X . . | coliforms/ml
scalding and chilling water

Significant increase or decrease at

1% level ——→
5% level - - →
10% level .....→

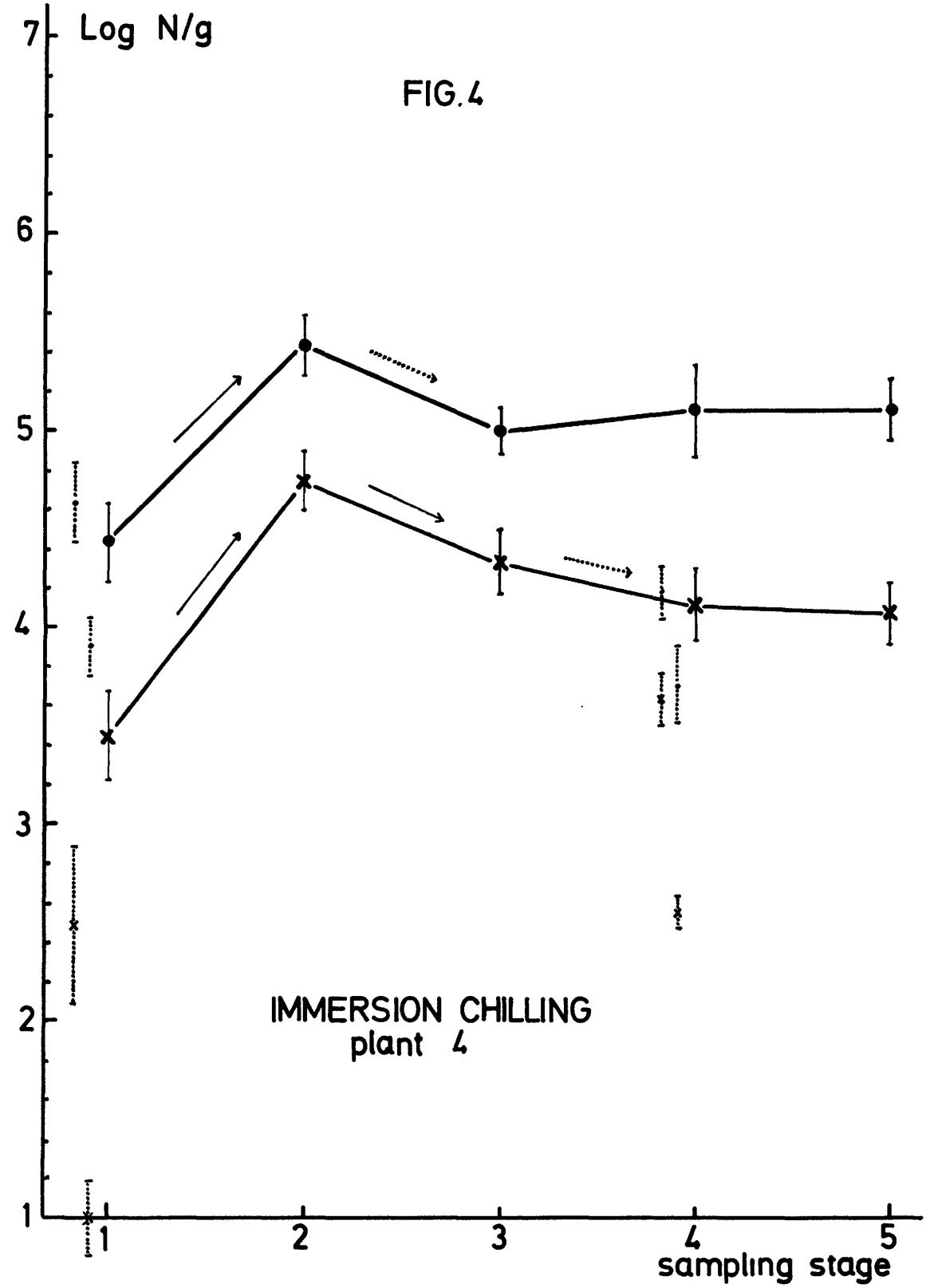

FIG. 4 : Geometric means $\pm$SEM[1] of bacterial counts at different stages of processing.

●——● | total count / g — neck skin
X——X | coliforms / g — neck skin

. . ● . . | total count / ml — scalding and chilling water
. . X . . | coliforms / ml — scalding and chilling water

Significant increase or decrease at

1% level ——>
5% level - - ->
10% level .....>

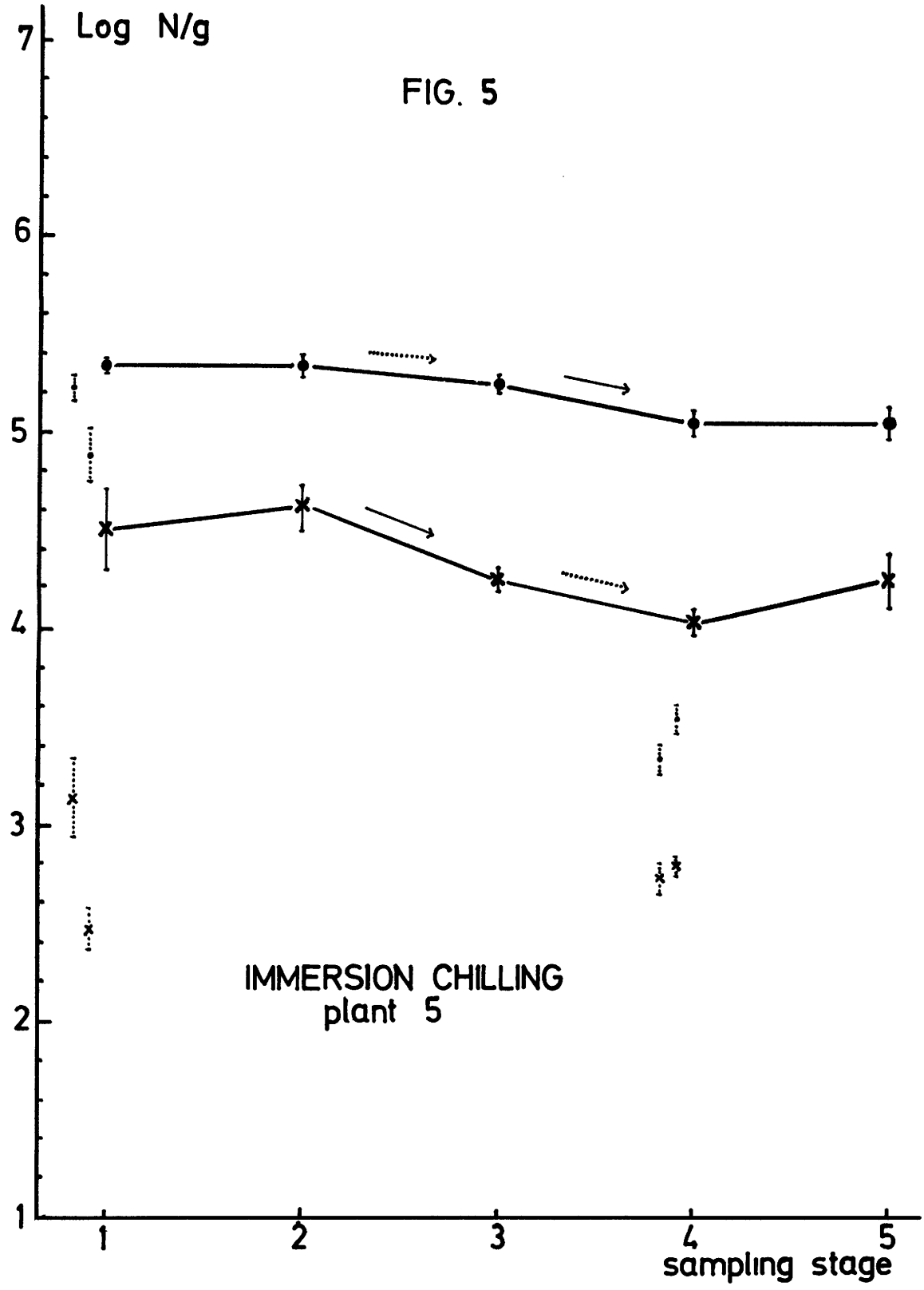

FIG. 5

FIG. 5 : Geometric means $\pm$SEM$_1$ of bacterial counts at different stages of processing.

Significant increase or decrease at

1% level ——→
5% level - - →
10% level .....→

●——● total count / g neck skin
X——X coliforms / g neck skin

. . ● . . total count / ml scalding and
. . X . . coliforms / ml chilling water

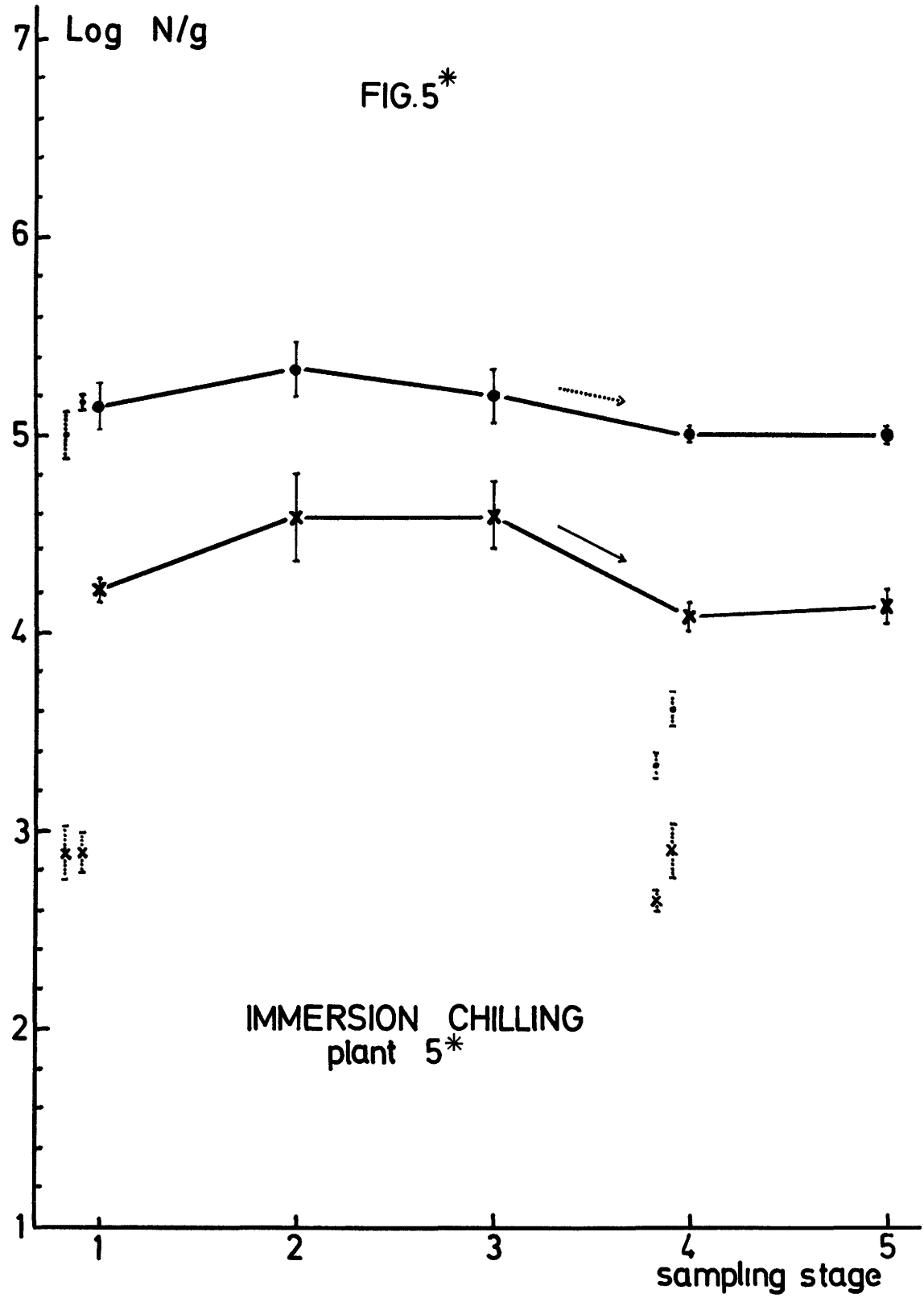

FIG. 5* : Geometric means ±SEM$_1$ of bacterial counts at different stages of processing.

●——● | total count / g — neck skin
X——X | coliforms / g — neck skin

. . ● . . | total count / ml — scalding and chilling water
. . X . . | coliforms / ml — scalding and chilling water

Significant increase or decrease at

1% level ——>
5% level - - ->
10% level .....>

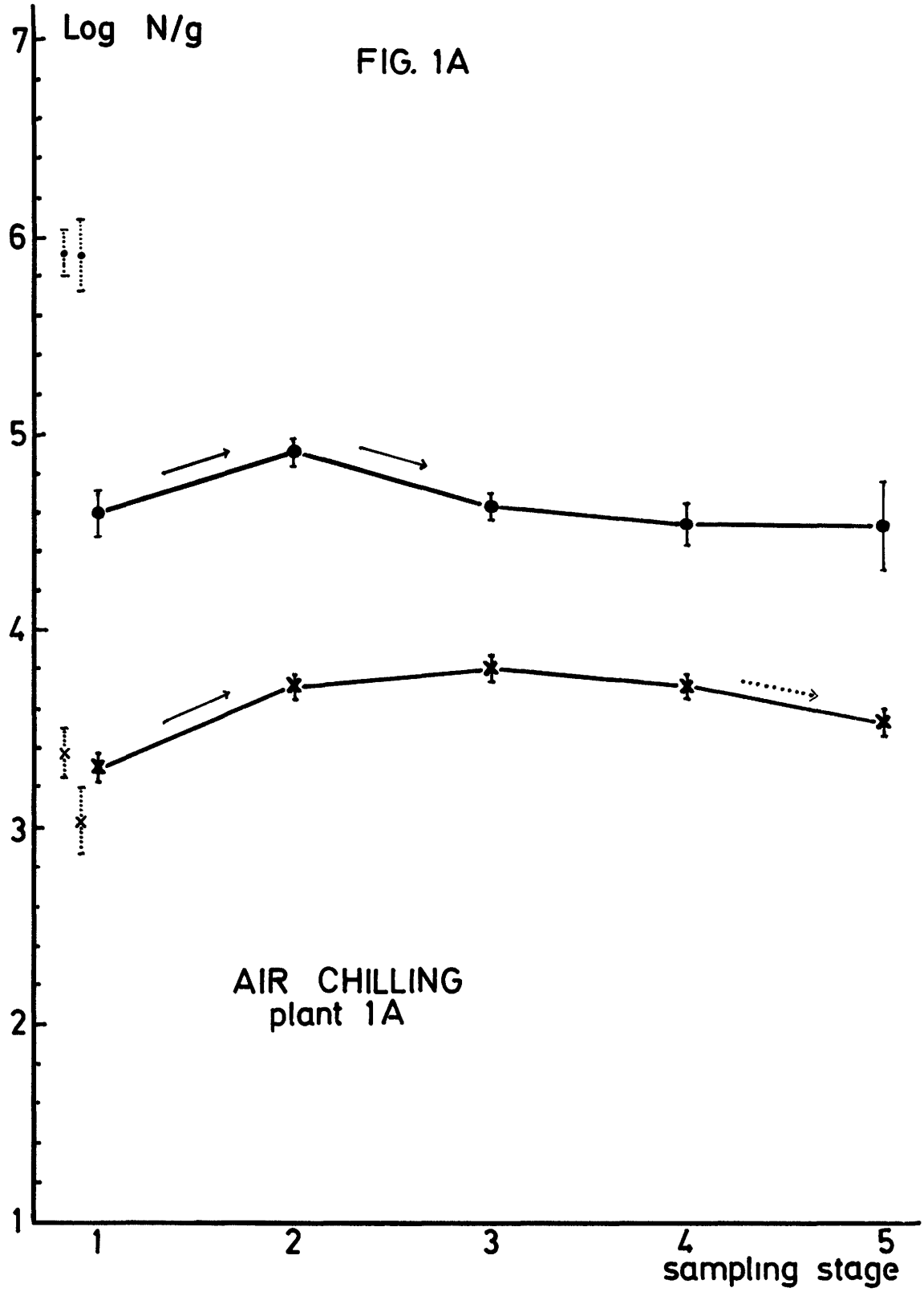

FIG. 1A : Geometric means $\pm$SEM$_1$ of bacterial counts at different stages of processing.

Significant increase or decrease at

1% level ——→
5% level - - →
10% level .....→

●——● total count/g neck skin
X——X coliforms/g neck skin

. . ● . . total count/ml scalding water
. . X . . coliforms/ml scalding water

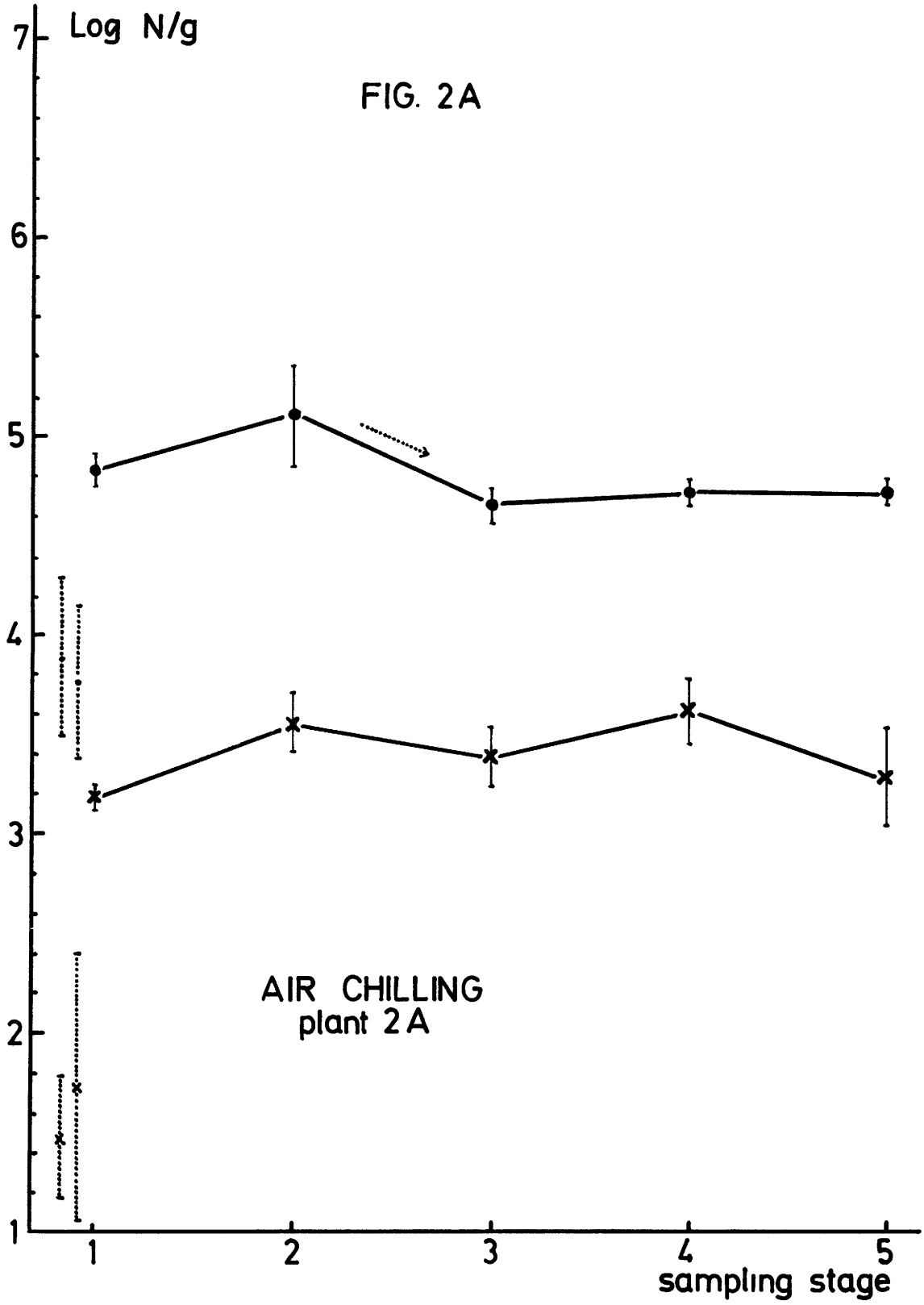

FIG. 2A

FIG. 2A : Geometric means $\pm$SEM$_1$ of bacterial counts at different stages of processing.

Significant increase or decrease at

1% level ——→
5% level - - →
10% level .....→

●——● | total count/g
X——X | coliforms/g
neck skin

. . ● . . | total count/ml
. . X . . | coliforms/ml
scalding water

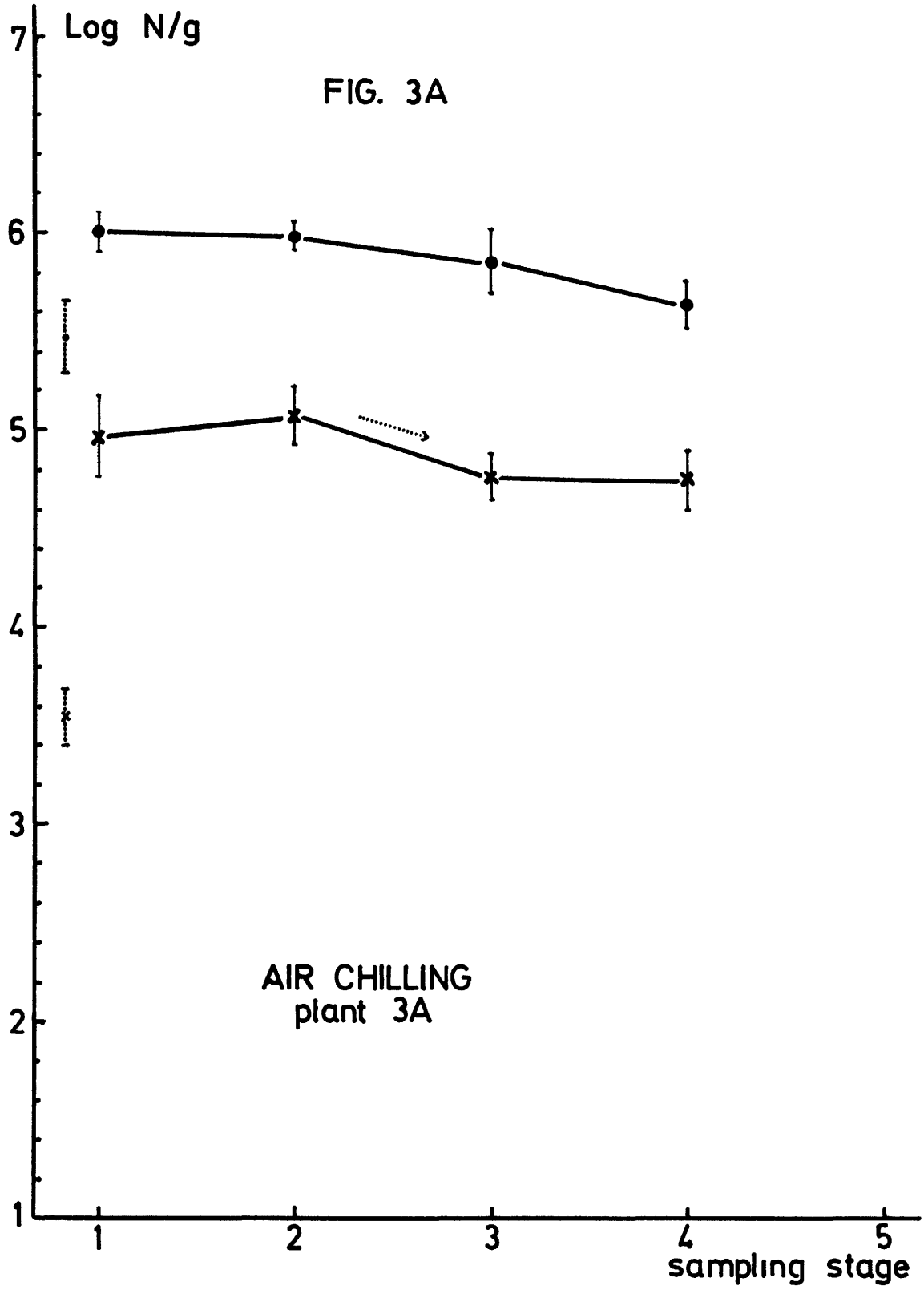

FIG. 3A : Geometric means $\pm$SEM[1] of bacterial counts at different stages of processing.

●——● | total count / g — neck skin
X——X | coliforms / g — neck skin

. . ● . . | total count / ml — scalding water
. . X . . | coliforms / ml — scalding water

Significant increase or decrease at

1% level ——>
5% level - - ->
10% level .....>

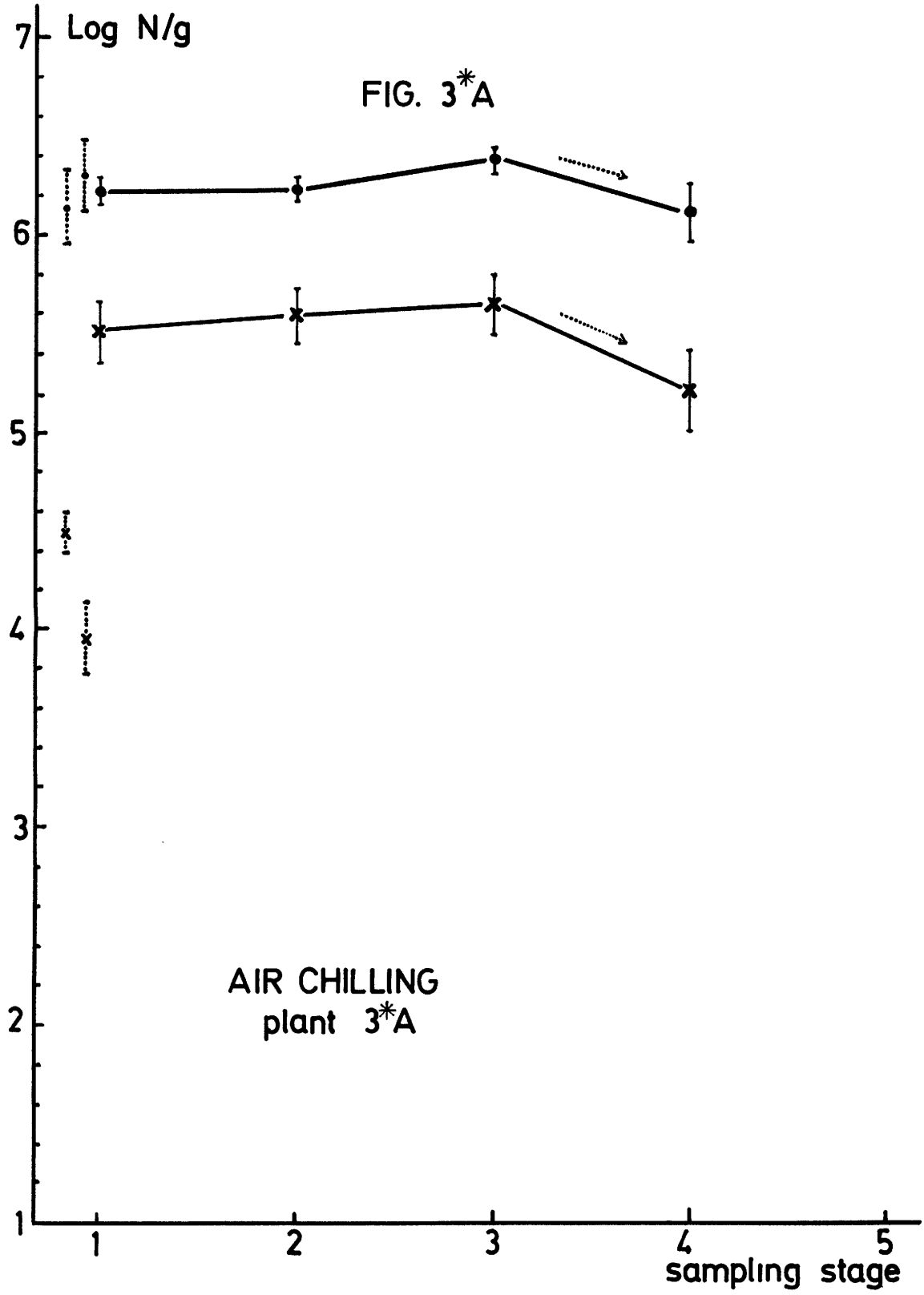

FIG. 3*A : Geometric means $\pm$SEM$_1$ of bacterial counts at different stages of processing.

●——● | total count / coliforms / g neck skin

X——X | total count / coliforms / g neck skin

. . ● . . | total count / coliforms / ml scalding water

. . X . . | total count / coliforms / ml scalding water

Significant increase or decrease at

1% level ——>

5% level - - ->

10% level .....>

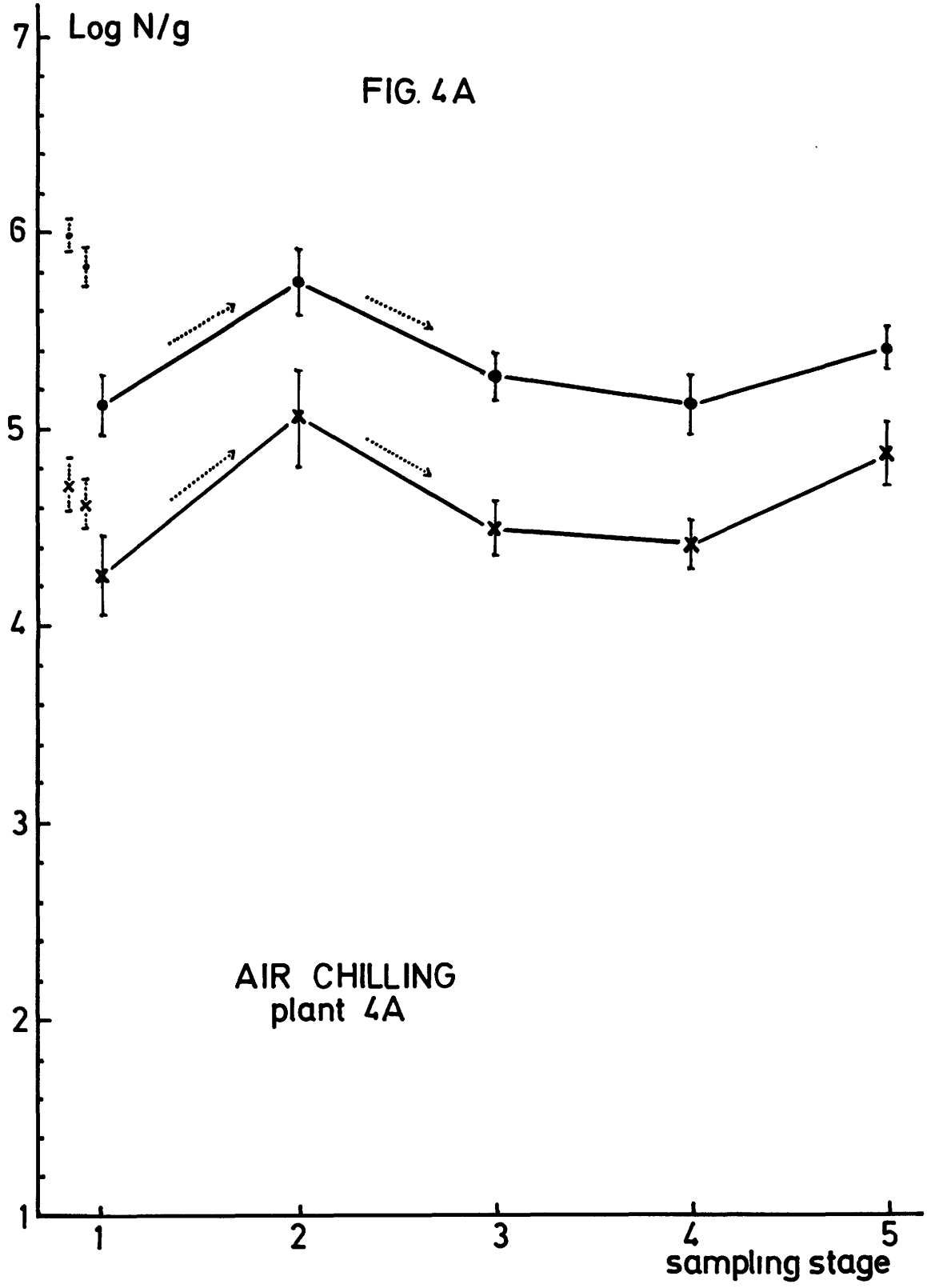

FIG. 4A : Geometric means $\pm$SEM[1] of bacterial counts at different stages of processing.

●——● | total count / g — neck skin
X——X | coliforms / g — neck skin

. . ● . . | total count / ml — scalding water
. . X . . | coliforms / ml — scalding water

Significant increase or decrease at

1% level ——→
5% level - - →
10% level .....→

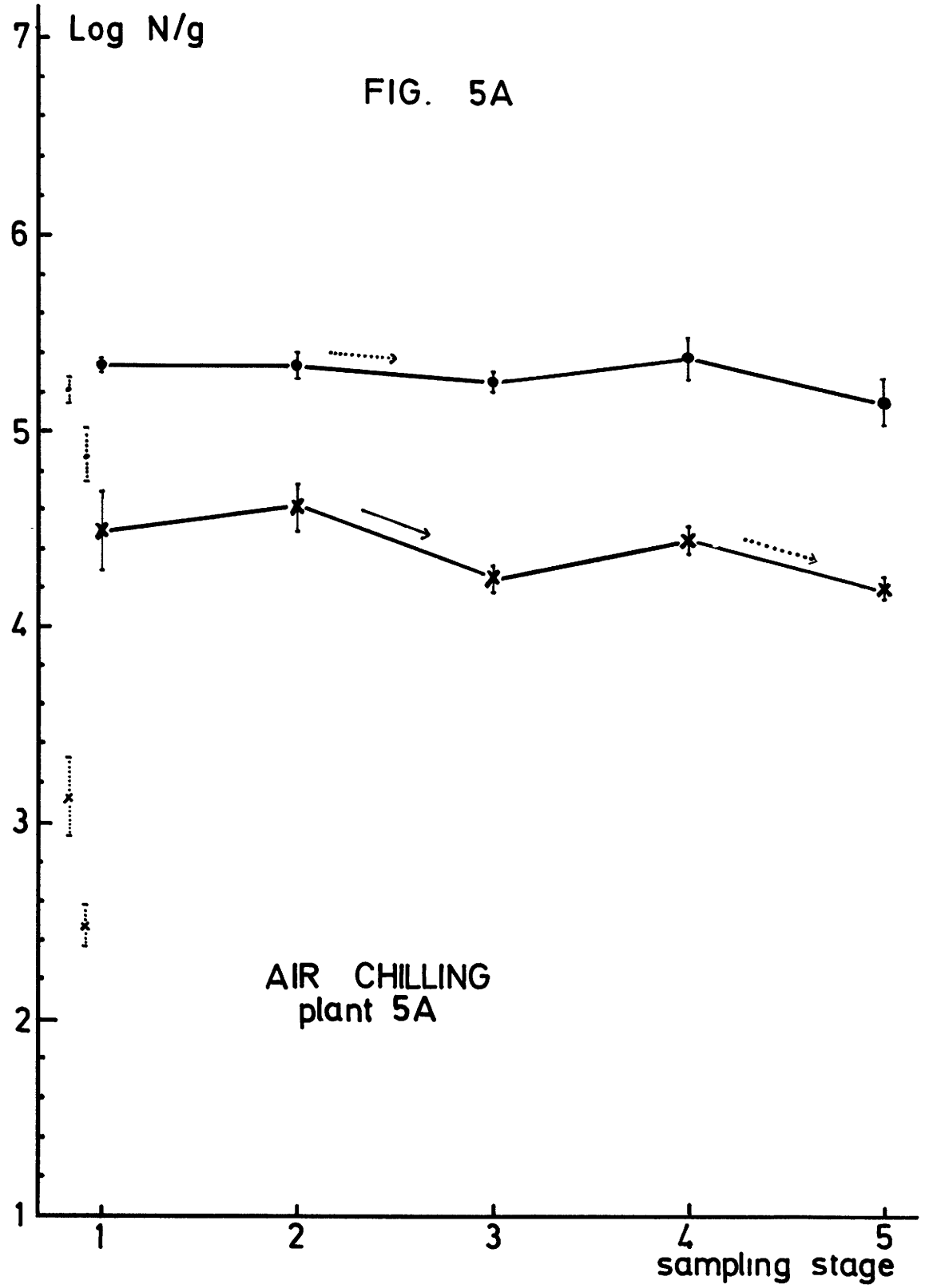

FIG. 5A : Geometric means $\pm$SEM$_1$ of bacterial counts at different stages of processing.

Significant increase or decrease at

1% level ——→
5% level - - →
10% level .....→

●——● | total count / g neck skin
X——X | coliforms

. . ● . . | total count / ml scalding water
. . X . . | coliforms

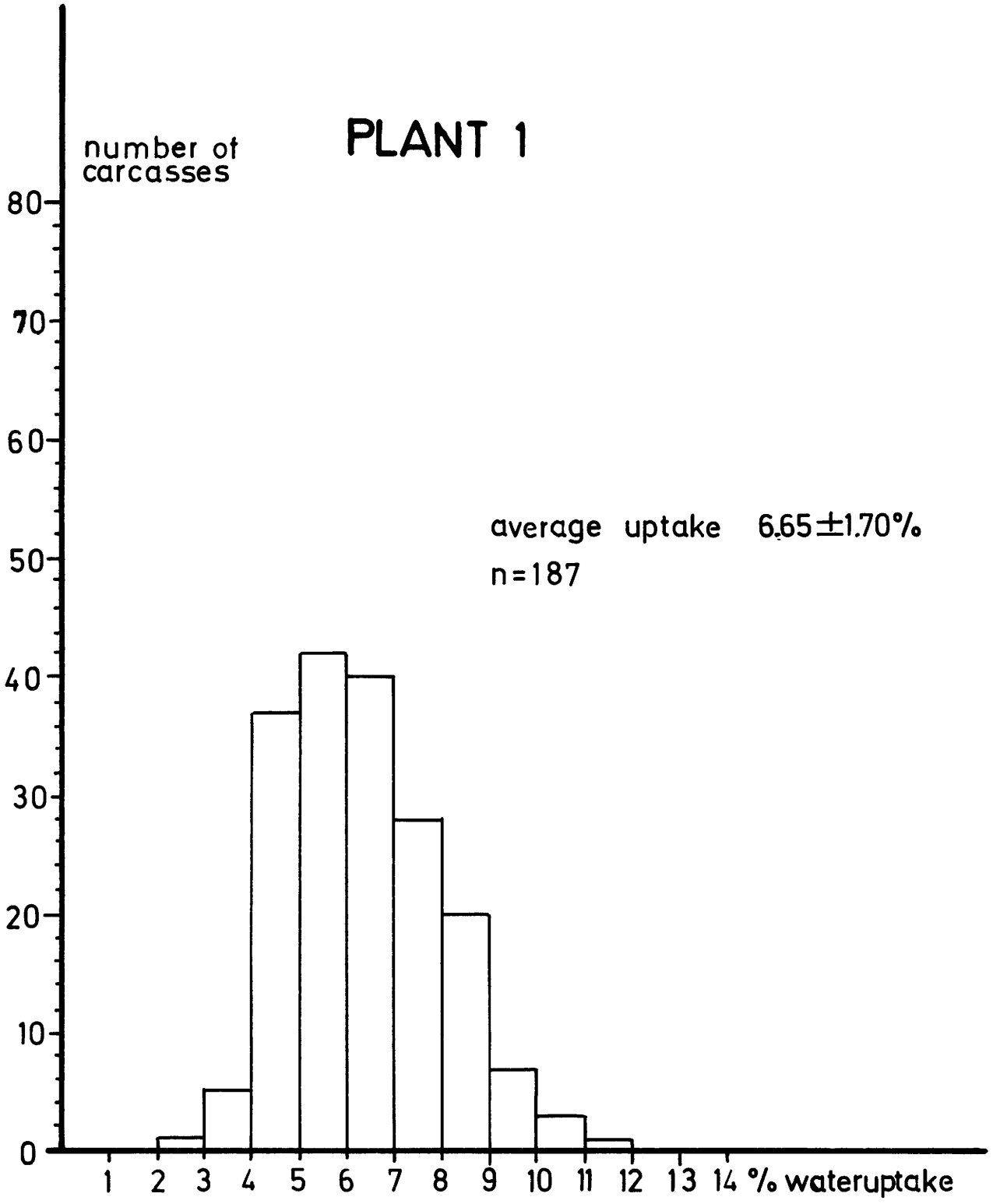

FIG. 6 : Average water uptake, measured by differences (in percent of initial weight $\pm S_1$) between weighings before spray-washer and at the exit of the immersion-chilling system, including usual dripping times.

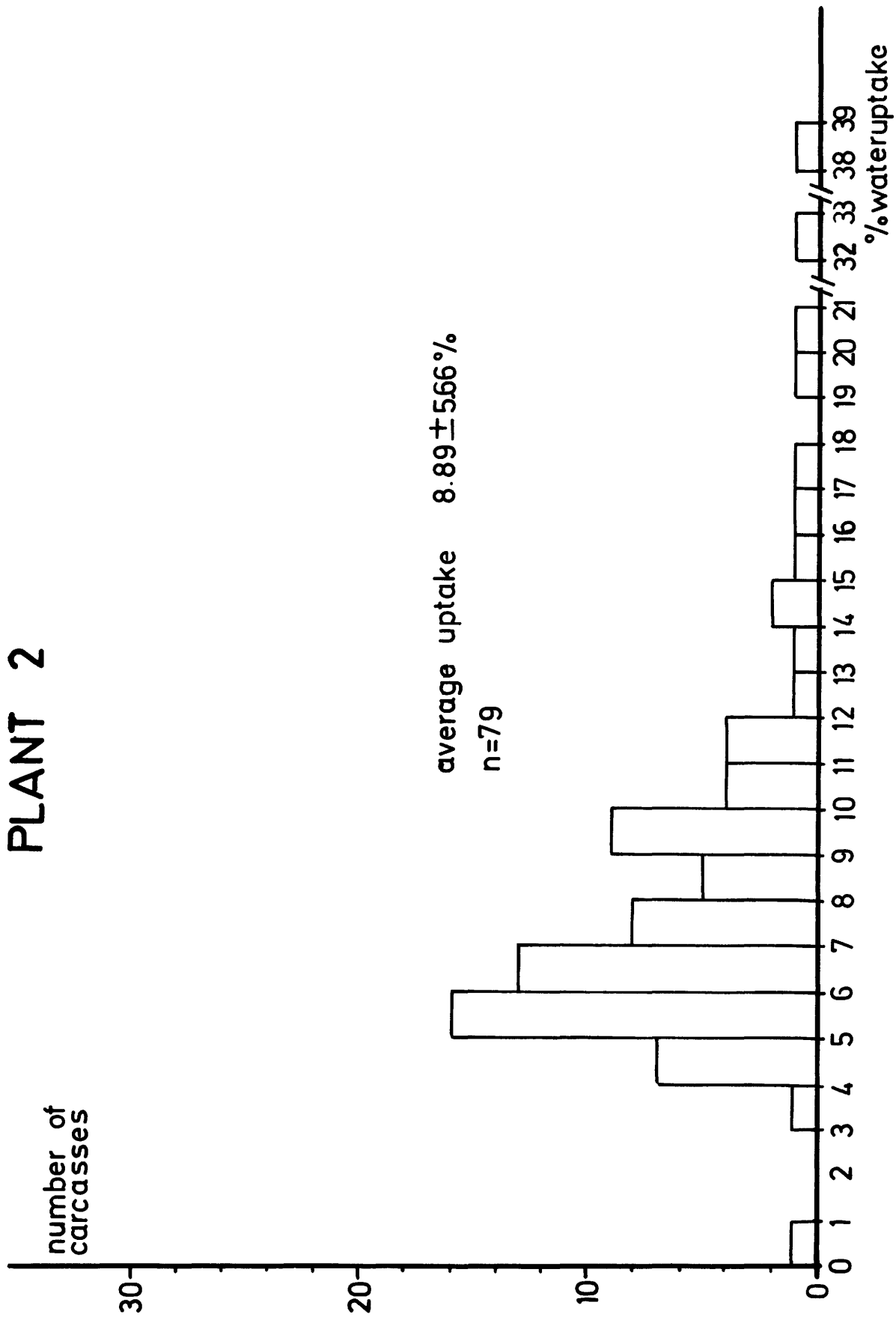

FIG. 7 : Average water uptake, measured by differences (in percent of initial weight $\pm S_1$) between weighings before spray-washer and at the exit of the immersion-chilling system, including usual dripping times.

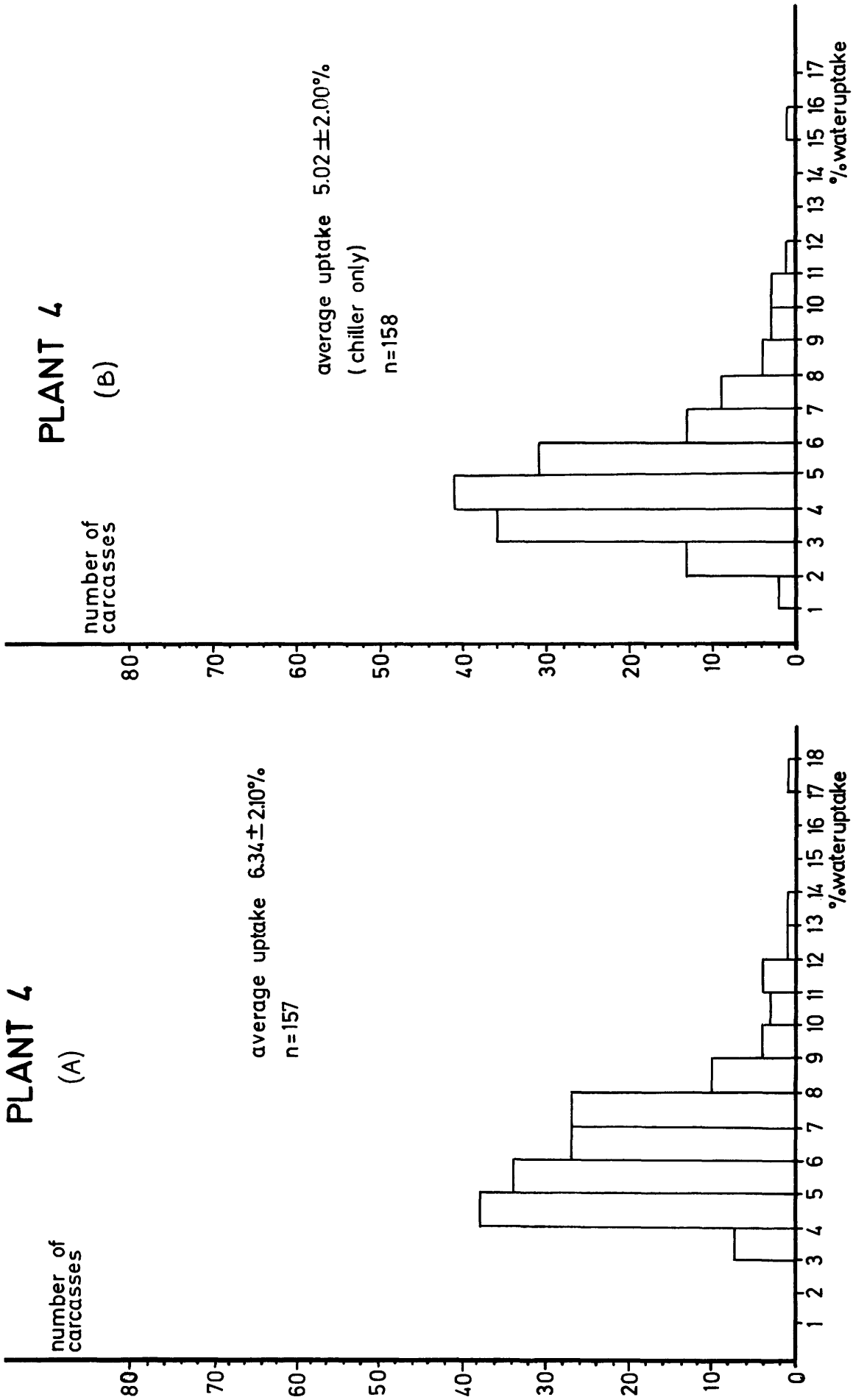

FIG. 8 : Average water uptake, measured by differences (in percent of initial weight $\pm s_1$) between
(A) weighings before spray washer and at the exit of the immersion chilling system, including usual dripping times.
(B) Idem, without water uptake during spray washing (chiller only).

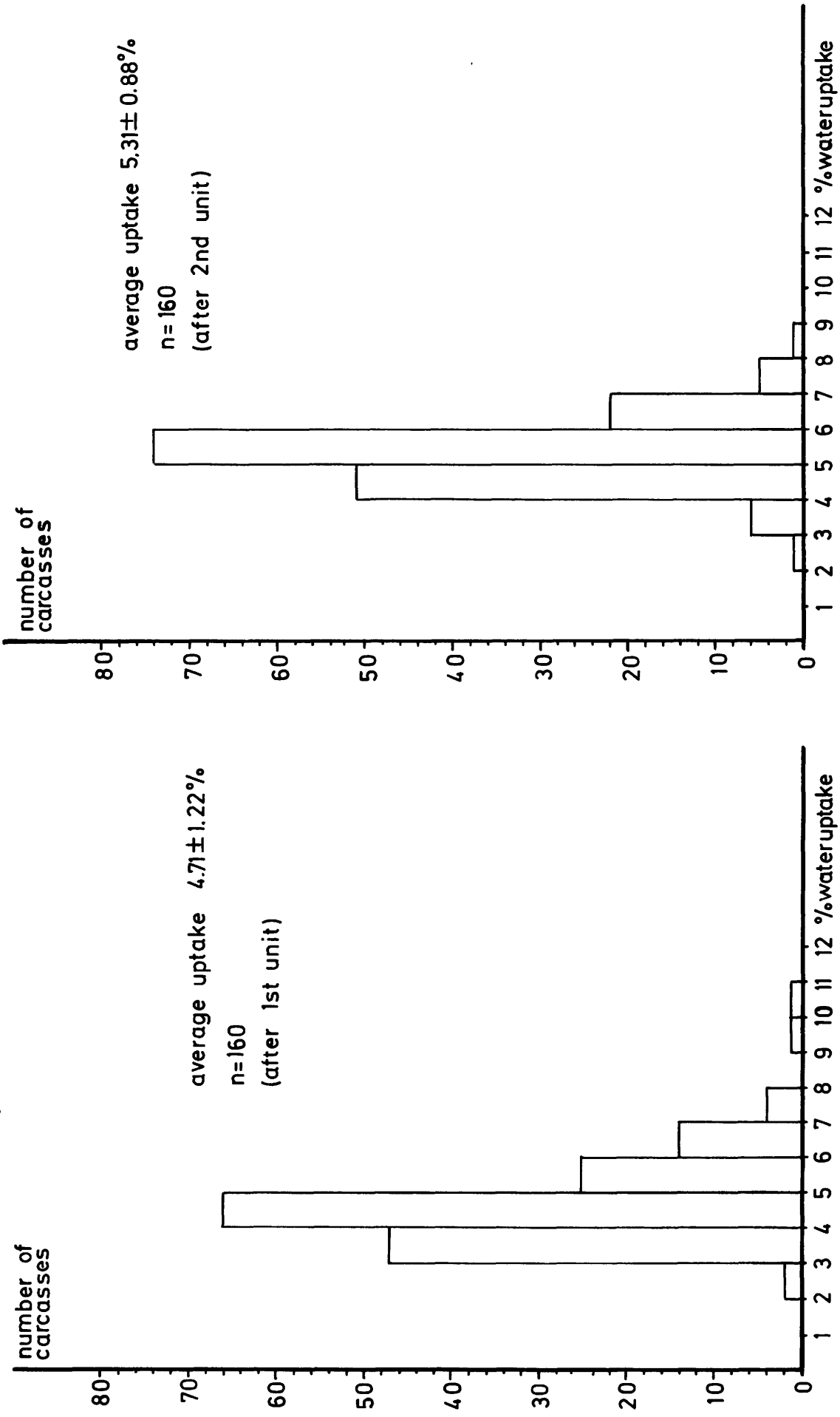

FIG. 9 : Average water uptake, measured by differences (in percent of initial weight $\pm S_1$) between weighings before spray-washer and at the exit of 1st and 2nd unit of the immersion-chilling system, including usual dripping times after 2nd unit.

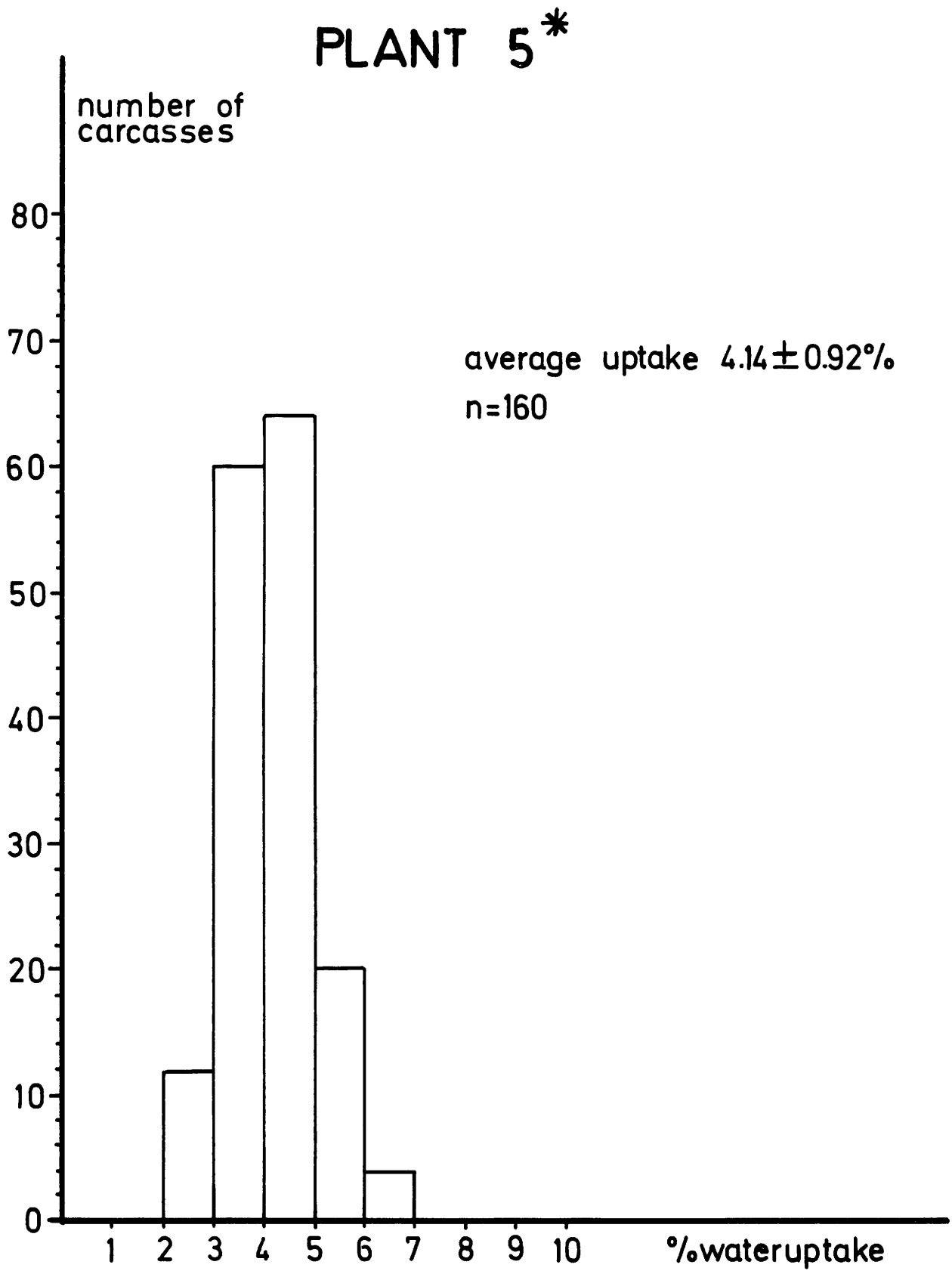

FIG. 10 : Average water uptake, measured by differences (in percent of initial weight $\pm S_1$) between weighings before spray-washer and at the exit of the immersion-chilling system, including usual dripping times.

Information on Agriculture

		Date	Languages
No. 1	Credit to agriculture I. France, Belgium, G.D. Luxembourg	February 1976	F
No. 2	Credit to agriculture II. Federal Republic of Germany	February 1976	D
No. 3	Credit to agriculture III. Italy	February 1976	F I
No. 4	Credit to agriculture IV. The Netherlands	February 1976	E N
No. 5	Map of the duration of the vegetationperiod in the Member States of the Community	March 1976	F D
No. 6	Models for analysis mixed crop and cattle farms Basic techno-economic data: Schwäbisch-bayerisches Hüggelland (Federal Republic of Germany)	March 1976	D
No. 7	Models for analysis mixed crop and cattle farms Basic techno-economic data: South-East Leinster (Ireland), West Cambridgeshire (United Kingdom), Fünen (Denmark)	March 1976	E
No. 8	Provisions on bovine husbandry	March 1976	F
No. 9	Forms of cooperation in the fishing industry – Denmark, Ireland, United Kingdom	April 1976	E
No. 10	The milk and beef markets in the Community – A regional approach for the achievement of equilibrium	June 1976	D E(1)
No. 11	The contribution of the "mountain communities" in Italy to the development of hill farming	July 1976	I
No. 12	The italian "enti di sviluppo agricolo" (agricultural development bodies) in the structural reforme – Ajustement problems and prospects	July 1976	I
No. 13	Markets for fresh lemons and lemon juice in the European Community	July 1976	E F
No. 14	Pesticide residues in tobacco and tobacco products I. General report	July 1976	F E
No. 15	Water content of frozen or deep-frozen poultry. – Examination of methods of determination	July 1976	F E(1)
No. 16	Methods for the detection of the viruses of certain diseases in animals and animal products	August 1976	E
No. 17	Veterinary Vaccines – A comparative analysis of regulations in the Member States for three major diseases	August 1976	E

(1) In preparation

		Date	Languages
No. 18	The foreseeable trend in world availabilities of agricultural products and the consequences for the Community I. Wheat, feed grain, sugar – Summary	August 1976	D F(1)
No. 19	The foreseeable trend in world availabilities of agricultural products and the consequences for the Community II. Beef, sheepmeat, milk products	September 1976	D F(1)
No. 20	Forms of cooperation between farms for production and marketing in the new Member States	September 1976	E
No. 21	Objectivation of the bacteriological and organoleptic quality of milk for consumption	September 1976	E
No. 22	Evaluation of the hygienic problems related to the chilling of poultry carcasses	October 1976	E

(1) In preparation.

Sales Offices

Belgique - België

Moniteur belge — Belgisch Staatsblad
Rue de Louvain 40–42 —
Leuvenseweg 40–42
1000 Bruxelles — 1000 Brussel
Tél. (02) 512 00 26
CCP 000-2005502-27 -
Postrekening 000-2005502-27

Sous-dépôt — Agentschap:
Librairie européenne —
Europese Boekhandel
Rue de la Loi 244 — Wetstraat 244
1040 Bruxelles — 1040 Brussel

Danmark

J.H. Schultz — Boghandel
Møntergade 19
1116 København K
Tel. 14 11 95
Girokonto 1195

BR Deutschland

Verlag Bundesanzeiger
5 Köln 1 — Breite Straße — Postfach 108 006
Tel. (0221) 21 03 48
(Fernschreiber: Anzeiger Bonn 08 882 595)
Postscheckkonto 834 00 Köln

France

Service de vente en France des publications des Communautés européennes
Journal officiel
26, rue Desaix
75 732 Paris Cedex 15
Tél. (1) 578 61 39 — CCP Paris 23-96

Ireland

Stationery Office
Beggar's Bush
Dublin 4
Tel. 68 84 33

Italia

Libreria dello Stato
Piazza G. Verdi 10
00198 Roma — Tel. (6) 8508
Telex 62008
CCP 1/2640

Agenzie.
00187 Roma — Via XX Settembre (Palazzo Ministero del tesoro)
20121 Milano — Galleria Vittorio Emanuele 3
Tel. 80 64 06

Grand-Duché de Luxembourg

Office des publications officielles des Communautés européennes
5, rue du Commerce
Boîte postale 1003 — Luxembourg
Tél. 49 00 81 — CCP 191-90
Compte courant bancaire :
BIL 8-109/6003/300

Nederland

Staatsdrukkerij- en uitgeverijbedrijf
Christoffel Plantijnstraat, 's-Gravenhage
Tel. (070) 81 45 11
Postgiro 42 53 00

United Kingdom

H.M. Stationery Office
P.O. Box 569
London SE1 9NH
Tel. (01) 928 6977, ext 365
National Giro Account 582-1002

United States of America

European Community Information Service
2100 M Street N.W.
Suite 707
Washington D.C. 20037
Tel. (202) 872 8350

Schweiz - Suisse - Svizzera

Librairie Payot
6, rue Grenus
1211 Genève
Tél. 31 89 50
CCP 12-236 Genève

Sverige

Librairie C.E. Fritze
2, Fredsgatan
Stockholm 16
Post Giro 193, Bank Giro 73/4015

España

Libreria Mundi-Prensa
Castelló 37
Madrid 1
Tel. 275 46 55

Other countries

Office for Official Publications of the European Communities
5, rue du Commerce
Boîte postale 1003 — Luxembourg
Tél. 49 00 81 - CCP 191-90
Compte courant bancaire :
BIL 8-109/6003/300

8878

FB 150,-	DKr. 23,60	DM 10,20	FF 18,-	Lit. 2750	Fl. 10,40	£ 1,85	$ 4.30

OFFICE FOR OFFICIAL PUBLICATIONS OF THE EUROPEAN COMMUNITIES
Boîte postale 1003 – Luxembourg

7165/22