APTEC Technology Consulting

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Semi-automatic Poultry Processing - Step By Step

(This document is complementary to the feasibility template you downloaded from the Aptec website)

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Contents:

1 The Product

The process produces fresh, hygienic chilled dressed whole chicken or frozen dressed chicken with skin-on[1]. Fresh chilled products are generally sold in plastic crates - packed in ice, while frozen products may be presented in crates - individually poly-packed. Depending on local market requirements, by adding inexpensive table-top disk cutters and doing manual deboning, or using a cone deboner which is an entry-level machine, it is possible to convert part of the produce into portioned chicken, curry-cut or deboned meat which are all value-added items. Fresh chilled products can be sent to the market for sale from refrigerated display cabinets. Or the product, as it comes off the line, can be blast-frozen and sent to the frozen store for long-term storage.

Transport is by refrigerated or insulated vans. The project costing in the companion feasibility templates assumes facility for blast freezing a quarter of the production and storage of blast frozen product. The remaining output is sold as fresh chilled, packed in ice in returnable crates or in ice-pack[2] coolers.

2 Business Models

Fifty years ago practically all chicken slaughter worldwide was done manually, often at the point of sale or consumption. This practice has been gradually phased out from most countries except some in South Asia and Africa. The practice of farm-gate sale of live birds for subsequent slaughter is called the wet market for chicken. Organised slaughter facility for chicken is preferred over wet markets because of obvious benefits to the environment, animal welfare, the industry and public health and the belief that rampant avian influenza and other diseases cannot be controlled unless wet markets are closed down worldwide.

At this point we might ask - who ventures into chicken slaughtering? Historically three main categories of investors have emerged.

a) The first is the chicken farmer whose operations have grown over the years and he now wishes to cater directly to the consumer instead of going through brokers that supply the wet market.

b) The second is the feed miller who is forced, from time to time, to buy out insolvent farmer-customers and inadvertently finds himself having to market live birds through brokers.

c) The third category includes supermarket chain owners and managers of large establishments (such as the armed forces) who are unable to source slaughtered chicken in sufficient quantities, of the right quality consistently over the year and at a competitive price.

In all these business models the prospective investor in a slaughter house happens to be in control of a significant part of the supply chain or marketing arrangement. In other words the model assumes a certain degree of integration. This is important. Under present market conditions, it is very unlikely for a ***merchant slaughtering facility***[3] to become viable in the South Asian context.

3 Land, Location and Layout

The layout requires a large plot of land. This will include the main slaughter plant, space provision for rendering plant, refrigeration and frozen store and administrative block, live chicken truck holding area (lairage), truck and crate washing area and electrical sub-station, all of which may be spread out on the plot and take up rather more than half a hectare. At least another half a hectare and preferably more area is set aside for wastewater treatment/aeration/settlement lagoons. Since Meyn/Systemate plants, be they however so small at the outset, are generally planned for convenient expansion, the layout should not be made small and restrictive in the beginning.

The site should be located along an all-weather road and should have adequate use of treated wastewater for agriculture or else, subject to local by-laws, should have a natural run-off for the same. Above all, the site should have year-round access to sweet and uncontaminated raw water, amounting, at the outset (at 1000

birds per hour processing), to 25 litre per bird slaughtered. As the project capacity expands, more water is required (although the specific per-bird water requirement falls). Therefore potential for more raw water and discharge of treated water should be considered to allow expansion.

Given the choice, we would recommend that you locate the plant closer to farms than the market. So a distance of 30-40 Km from commercial farms is good. The market may be more distant - even a distance of 200+ km is quite operable unless the bulk of your supplies must be in the form of fresh chilled birds. Other relevant factors are proximity to labour, distance from thickly populated areas and access to power and telecommunication facilities.

A word about government industrial estate and food-park land. Assuming that the land is priced right for all the infrastructure it provides (power, road, water and reduced red tape), it is imperative that there be an **existing common** wastewater treatment facility. The emphasis is on both **existing** and **common**. If it is not existing from the time you start operation, you will have to create your own facility, and if they have plans of adding their common facility "later on", then to make it viable, they will likely force you to scrap your own! These agencies need to grow out of their role as real estate agents and mature into industrial infrastructure providers. Till they do so, you are safer with greenfield plots.

On the other hand, industrial estates that are ready to take in your effluent outflow at about 260-290 BOD_7 and treat it, before discharge, to a level of 8.5 to 25^4 constitute a definite advantage over a greenfield site

Bottom line : if a government industrial estate has plans to **add** a common effluent treatment facility **later on**, that land is not suitable for this project.

4 Buildings

Two distinct construction styles are popular internationally, and the choice would depend on relative cost and convenience.

a) The first is an RCC frame building with brick walls with an RCC in-situ cast roof for the main process area (designated in the companion feasibility template as slaughter house) and a steel frame building with GI sheet roofing and PU sandwich panel walls and false ceiling for cold areas (designated in the accompanying template as packing, refrig., frozen store areas). The rendering building is special, consisting of 3.5 floors and generally built for a large static load, therefore it must be of RCC frame, brick walls and RCC floor slabs. Feasibility template rows 2.4 to 2.8 can be of any type of construction.

b) The second is entirely based on PU sandwich panels, although here also it is essential to use the RCC style for constructing the rendering block.

The choice depends on the entrepreneur. It is true that panel construction is quick and neat, but when used in the slaughter house area, it presents certain difficulties - internal load-bearing steel structural supports for mounting the processing machinery must be provided additionally as the panel is not strong enough.

Construction	**Recommended type**	**Construction**	**Recommended type**
Live bird arrival and hanging veranda (Ambient)	A	Rendering block	**F**
Killing, defeathering and evisceration (Ambient)	**B**	Administrative block	**E**
Packing/Portioning Room (at +12^{o}C)	**C**	Bird lairage (in cages with cooling fans)	**G**
Sub-zero areas (BF at -35^{o}C, frozen store at -18^{o}C)	**C**	Offal pit room	**E**
Utility Building	**D**	Control switchgear Room	**E**
Electrical Sub station	**E**	Offal pit (in cubic metres)	**H**
ETP (civil part)	**E**	Machine foundations (in M^3)	**H**
Gate house, plant security etc	**E**		

If your plant is initially sized with the view that it will go through several stages of expansion over the next couple of years, we would strongly recommend type (a) construction.

Constructions having GI sheet roofing without false ceiling are quite unsuitable for slaughter and packing, refrig, frozen store and rendering areas. We do not recommend use of asbestos sheet roofing even when the material is sold under misleading names like "fibre-reinforced cement sheeting"

Construction component	A	B	C	D	E	F	G	H
Walls								
RCC column with brick walls	x	x		x	x	x		
PU Panel with outer protection wall			x					
With glazed tiles up to 3 m ht	x	x				x		
If tiled brick, enamel paint 3 m to ceiling	x	x				x		
Roof								
RCC slab cast over beams or	x	x	x		x	x		x
GI sheeting over steel trusses	x	x		x			x	
False ceiling if truss supported roof	x	x						
Insulated ceiling			x					
Painted ceiling	x	x				x		
Ventilation monitors near ceiling	x	x						
With load bearing suspension points	x	x	x			x		
Flooring								
IPS								x
Dewatered granolithic flooring						x	x	
Kota stone or vitreous tiles	x	x	x					
With insulation			x					
Anti-heave treatment by embedded tubes			x					
Floor gutters with steel grille covers	x	x	x					x
Doors								
Washable with shatter-proof glazing	x	x						
Self closing	x	x						
Insulated, panel type, sliding		x	x					
Any type					x			
Any type				x	x	x		
Windows								
Washable, with shatter-proof glazing	x	x						
Washable with double glazing			x					
Wood/Steel/Aluminium with glazing				x	x			
Wire gauze only				x		x		
RCC foundation block								x

5 Functional Sections

This document gives section-wise details of a semi-automatic poultry processing plant. The same plant can be used for processing broilers, spent layers and breeder culls, but cockerels are quite difficult to hang in normal shackles as their hocks are very thick.

All modern process houses have a high degree of automation. In industry parlance, a semi-automatic plant refers to " a high degree of automation in all areas except evisceration which is almost entirely performed by personnel using pneumatic hand tools". Therefore a fully automatic plant means one in which even the evisceration (EV, consisting generally of 6-7 machines) is automated. Full automation is necessary where the **line speed is high or where manpower is hard to recruit**. At high speeds human operators holding passive

and pneumatic hand tools are unable to cope. Semi-automatic plants supplied by us can be upgraded by the addition of automatic evisceration machinery as they grow and the capacity warrants it.

A chicken slaughtering plant in semi-automatic configuration can be supplied either in the standard 1000 birds per hour version, or by omitting alternate shackles, in the 500 birds per hour version at a marginally lower cost. Any of our semi-automatic plants can be upgraded over a week-end and if our preferred and recommended layout is followed, the same plant is capable of rapid expansion up to 4000 or 6000 birds per hour depending on initial layout. All our plants can be operated up to about 18 hours a day and we can comfortably assume 330 working days a year if preventive maintenance is done.

5.1 Slaughtering

In the semi-automatic slaughtering configuration, the line consists of the following machines/sections. More sophisticated configuration is possible, but neither necessary nor advisable in a start-up venture. In this listing, only those machines required for small plants as featured in the feasibility are named. Alternatives to these basic machines are mentioned and discussed in the slaughter description section. Please look at the top descriptive lines in the feasibility spreadsheet for listing of machines specific to your choice.

5.2 Killing Section

Overhead killing line conveyor with shackles, drive and lubrication system	In small plants it is usual to combine killing and evisceration in a single line
Water bath stunner	Where stunner is not used (e.g. for religious reasons) strenuous wing flapping after halal results in a very high percentage of wing damage
Blood trough, locally fabricated to our design	A stainless steel modular trough or a brick/concrete trough with glazed tile lining
Jacuzzi or Jet Stream scalder	The minimum size for which we can offer the more efficient, and lower cost jet stream scalder is 2000 BPH. All other size operations use the familiar jacuzzi scalder with highly precise temperature control.
Feather plucker	For removing feathers from scalded carcasses
Head-puller	For efficient evisceration it is necessary to pull of rather than cut off heads
Hock or foot cutter	Hock cutter is standard. Foot cutters produce carcasses which are not generally acceptable in India. Where a combined killing-EV line is offered, the hock cuter is placed at the end of the line - after evisceration
Chain and shackle washer	Essential for product hygiene. More so in a combined line

5.3 Evisceration Section

Overhead EV line conveyor with shackles, drive and lubrication system	Offered only where a combined line is not
Evisceration trough or belt, if trough, locally fabricated to our design	In semi-automatic evisceration the action is performed with the use of pneumatic tools over this trough/belt
Pneumatic vent drill(s)	Pneumatic tool for cutting around cloacca without damaging the bursa and without spilling contents of the gut
Hand tools	
Pneumatic/vacuum lung pistol(s)	Pneumatic tool for removal of lungs and tissue debris
Gizzard peeling system	Removes the horny yellow skin lining the inside of the gizzard
Pneumatic neck cutting scissors	Used only where the customers wants carcasses with neck off
Carcass washing system	Outside washing spray cabinet, locally fabricated to our design
Automatic cropping machine	One of the automatic evisceration machines which does a more thorough job than manually possible
Automatic inside-outside bird washer	One of the automatic machines in the evisceration section that performs better than humans can

Shackle washing system	essential for product hygiene.
5.4 Chilling Section	
Spin chiller(s)	Essential for rapidly cooling, in a cost effective way, the carcass to prevent spoilage. Performance of dip tanks with slush ice cannot be compared to the results that can be obtained with this machine
Drip rack, locally fabricated to our design	To remove excess water from the carcass
5.5 Weighing and Grading Section	
Table top electronic weighing machines	For manual weighing and grading of portions, whole carcasses, and tray packs
Automatic weighing and grading machine	A completely automated computerized line incorporating a highly accurate weighing machine and destination bins that may range in number from 8 to 32. Vastly improves efficiency, product control and manpower deployment
5.6 Portioning and Packing Section	
Packing tables	SS tables locally fabricated according to our design. These are used for manual portioning, manual deboning, manual grading and packing
Semi-automatic bird bagger(s) or Bagging horns	With the correct type of wicket bag this produces a neatly packed whole carcass. The semi-automatic machine has a higher throughput and produces neater packages
Tape sealer	To seal off the wicket bags
Disk cutters, locally sourced	For portioning carcasses
Cone deboner	An efficient machine for producing large quantities of portions and breast fillets.
Japanese cut-up line	A larger and more efficient system than the cone deboner.
5.7 Auxiliaries	
Offal handling section	The backbone of efficient and hygienic operation is an automatic offal removal system. By this offal and feathers are not touched by plant staff and this results in good hygiene. The system consists of floor gutters, one or more powerful slurry pumps and a high efficiency screen
Crate washing section	Two types of crates are used in extensive slaughter operations. Automatic crate washing reduces manpower and ensures consistent and hygienic operations

6 Utilities

6.1 Refrigeration

The refrigeration section serves the following needs:

a) Chilled water for supply to the spin chiller(s) (at + 2 ^{o}C)

b) Supplementary ice for the spin chiller (at 0^{o}C to -12^{o}C)

c) Ice for packing fresh chilled product for dispatch (at 0^{o}C)

d) Blast freezers and plate freezers, where required (at -40°C

e) Frozen store (at -18 °C)

f) Chill store and maturation store (at 0°C)

g) Cooling working area like packing room, common areas for product dispatch and product movement within the plant. (at +12°C). These requirements cannot be served by window air-conditioners.

Therefore the first point to be noted is that this section must never be under-sized. The capital outlay for this section is typically much higher than that for processing equipment in small semi-automatic plants.

Slaughtered chicken is water-chilled to bring its temperature down from around +38° C to under +6° C by keeping the carcasses for around 25-30 minutes in the spin chiller. To help the chilled water percolate by allowing birds to sink, the water bath has built-in air agitation. Also, heat transfer is aided by using a counter-current chilling method. Fresh chilled water is supplied at as close to freezing temperature as possible. In water chilling some amount of water pickup occurs so that the yield is typically around 102-103% w/w even after the carcasses are allowed to drip to remove excess water.

Cooling below +6°C is possible only if the cooling water is supplemented with ice, preferably in the form of flakes. If the flakes need to be stored, they must be at -10°C, else they stick into lumps.

Besides water-chilling, for adequate preservation till they reach the point of consumption, chickens need to be chilled further. This is done by blast freezing the carcasses using blasts of chilled air of around -40°C till the surface temperature reaches around -35° C (at which time the core temperature is around -10° C). Then the chickens are transferred to the frozen store, where, in less than 24 hours, the temperature equalizes to around minus -18° C. This then gives the product an enormously long shelf life of up to a year.

Air chilling is also useful for further chilling of chickens targeted for sale as fresh chilled. In this case the carcasses are cooled to a temperature just above 0° C. However although it has some advantages, air chilling is more expensive and requires more capital to set up and therefore it is not likely to become popular in Asia for some time. It is standard only in Europe.

Fresh chilled chickens are packed in crates with ice, typically shell or tube ice weighing around half as much as the payload. Chickens treated in this manner, provided they are always kept in ice, are capable of lasting for 3-4 days under ideal conditions. Fresh chilled chickens are soft to the touch and do not need to be thawed before cooking. In this respect they appear more acceptable to consumers who are used to freshly slaughtered chicken from the wet market.

Blast frozen chickens are typically not sold immediately after slaughtering. The main benefit of blast freezing is to be able to preserve chickens for long periods of time to smoothen out supply and demand mismatches and to control market slumps arising out of these irregularities. Blast frozen chickens are hard to the touch and to that extent appear "different" to such buyers who are used to the wet market.

Blast freezing must be very rapid after chicken comes out of the spin chiller. This can only be achieved by a suitably large refrigeration capacity. The importance of rapid freezing and maintenance of a tight cold chain to product quality and keeping properties cannot be over-emphasized.

When chicken are frozen slowly (as in the case of a low powered freezing chamber or when chilled chicken are placed in a freeze display shelf of a refrigerator), proteins in the meat get denatured and the product never tastes good anymore[5]. Therefore slow freezing or re-freezing is the worst treatment you can give to your product.

The maturation store is necessary if you aim at producing very high quality fresh chilled deboned products. Placing chilled carcasses in the maturation chiller for 4-5 hours at 0°C before they are portioned and deboned results in very soft and tender product.

Refrigeration forms not only a large part of the investment but also accounts for the larger part of the processing cost. Therefore it is useful to consider (a) the relative advantages of alternative technologies and (b) system configuration - whether you should opt for a centralized bank of compressors or a distributed array of compressors.

Ask us to help you decide so that your operating cost is minimized.

6.2 Raw Water

Raw water is treated by filtration and chlorination or other means depending on initial quality, to reduce bacterial count and is pumped into an overhead tank. From here the water flows down to the water chilling plant, the slaughter plant, wash areas and all domestic water lines. The tank must be at least 10 metres above the ground to create sufficient pressure. Because water requirement in the plant is intermittent, it is useful to have a large diameter main header from which the supply lines are taken to different consumption points.

Generally the rendering block is designed to hold the overhead water tank. At 3 floors it already has the requisite height - the water tank gives it an additional 1/2 floor height.

6.3 Hot Water

Hot water or steam is required for heating the scalder. In installations where rendering plants are installed or proposed, it pays to plan from the beginning for steam heating. Then the rendering cooker and scalder can share the steam from the same boiler. Steam is generated typically in an oil fired package boiler which supplies it to demand at 10.54 Kg/cm^2. This high pressure steam is required in the rendering plant. For the scalder, the steam is supplied at a lower pressure of 2 Bar through a pressure reducing valve.

Many chicken processors have benefited by using agro-waste for making steam. Look around carefully in your area for such agro-wastes. Typical wastes are coconut shell, coconut leaf stem, paddy husk - either fresh or spent litter, and we will help you design a low operating cost steam raising facility.

6.4 Compressed Air

An air compressor with a storage tank is required. The compressed air is at 8 bars pressure and needs to be dried by a refrigeration type drier. Silica gel systems are not effective for chicken processing in tropical climates.

6.5 Vacuum

Vacuum is required for suction of lungs from carcasses using lung-sucking pistols. It is also used for transport of blood from the bleeding tunnel to the rendering plant or disposal. For this a water-ring vacuum pump capable of generating 100 mm of water column and two holding tanks as well as the requisite piping with swept bends are required.

6.6 Power

Power requirement for such a 1000 BPH plant is of the order of 350-450 kVA, but the actual depends very much on the refrigeration load. Load of the slaughtering section is minimal.

It is easy to make inadequate provision for power in a chicken slaughtering plant. To give you an idea, tabulated below is the connected load data for different sections of a 2000 birds per hour plant designed to operate around 10 hours per day. Of these, the rendering plant, effluent treatment plant and cold store and ice bank tank are designed for 24 hour operation. Design the backup power supply to ensure economy.

Slaughtering section	77 kW
Rendering	65 kW

Refrigeration	390 kW
Other	158 kW

6.7 Effluent Treatment

Wastewater from the plant goes into a buffer tank via a fat trap. The buffer tank is sized to hold the wastewater generated during the operating hours and feed it over 24 hours into the treatment facility. After treatment, where it is made to meet environmentally acceptable quality standards, the water is discharged as fit for irrigation purposes. Wastewater streams as discharged from the plant are composed as follows:

The wastewater characteristics are typically:		
	Slaughter	**Rendering (20-40 Kl/day)**
COD	3500/4500 ppm	5000/6000 ppm
BOD	2300/3000 ppm	3000 ppm
Suspended solids	1500/2000 ppm	500 ppm
Oils and fats	1500/1800 ppm	---
Kjeldahl nitrogen	200/250 ppm	500/600 ppm
H_2S	----	300 ppm
NH_3	----	350 ppm

7 Slaughter Description

Trucks bringing live birds from nearby commercial farms are carefully scheduled to ensure steady supply, with movement commencing in the relatively cooler hours of the day.

Birds arrive preferably in top-opening plastic crates which are removed from the truck and loaded onto a terrace or veranda. From here a person carries the crates to the hanging man, who flips open its top lid and, withdrawing the birds, hangs them by their feet onto the moving shackles. One person can comfortably hang a thousand birds an hour provided birds are presented to him in such crates on a roller conveyor. For up to 1000 birds an hour a roller conveyor is useful but not essential.

7.1 Hanging and Killing

In under a minute the hung birds pass into a water-bath stunner. Here their heads dip into a small pool of water where they experience a mild shock which stuns them. After stunning they may be killed by the Muslim ritual Halal method or by any other manual or mechanical method. In small plants manual killing is preferred as it is cheaper and in many instances mandated for religious reasons. This is performed while the chicken are in a stunned condition. Here again one person can comfortably kill a thousand chicken an hour. Chicken are allowed to bleed into a bleeding trough for approximately 1820 seconds (in case of manual killing as in Halal) during which time they lose approximately 50% of their blood content. This is the maximum amount of blood that they can lose under the circumstances.

7.2 Scalding

After this the birds are scalded. The scalder is a bath of water held at +57 to +58 ^{o}C into which the birds are dipped. This temperature is suitable for hard scalding. Facilitated by a powerful air agitation of the water in the scalding tank (or a jet stream as in Meyn Jet Stream scalder), the feathers are soaked loose. Scalding has a great influence on the result obtained on plucking and therefore on the quality of the final product. Depending on the temperature setting and duration of scalding, the birds may be *hard-scalded* or soft-scalded. Hard scalded birds are suitable for blast freezing while soft scalded birds are generally better sold fresh air-chilled. In Asia hard scalding is universally preferred. For a detailed technological comparison and capital cost implication on the choice between these scalding methods, please contact us.

Scalding is THE KEY STEP determining bird quality. Meyn and Systemate use precision controllers to ensure temperature control with better than 0.2 degree centigrade variance from the set point !

When using hard scald method it is essential that the line does not have to stop for any reason. At any given time 13 or more birds may be in the scalder. If they stay in hot water for even a minute in excess of the prescribed 2 minutes travel time, they get ruined.

7.3 Plucking

Scalded birds are moved by the conveyor to the feather plucker. The plucking operation is performed by passing the birds, still on the shackle line, between pairs of rapidly spinning discs, each having several flexible rubber fingers. Assisted by a small spray of water, plucking fingers develop enough adhesion with feathers which have been adequately pre-loosened during scalding, to cause them to be removed.

Plucked birds then pass over the head-puller. Here the heads are pulled off the birds as they pass overhead. If the killing operation has not damaged the trachea, it gets pulled off along with the head. Else an additional person is required for removing it along with the crop after the evisceration operation. At above 2000 BPH it is economical to automate the crop removal part using a cropping machine.

7.4 Evisceration

Most of the evisceration operation is performed over an evisceration trough which is made of stainless steel and provided with wash stations, tool holders and running water to carry away the offal.

The first step in evisceration is performed by a vent drill which is a pneumatic tool. With this a tubular knife makes a circular cut in the abdominal wall around the cloacca and while the tool is being withdrawn, pulls out the disk of flesh along with the *bursa fabricius* and the large intestine attached to it. In this action, none of the content of the gut is spilled into the body cavity, nor is the bursa damaged. Consequently it is an important step in the hygiene and quality of the final product. A skilled operator using one vent drill can slaughter two thousand birds per hour.

As the bird passes to the next operator, using an opening knife, he enlarges the circular cut. The next person uses an evisceration fork to scoop out the entire pack consisting of the intestine, liver, heart, gizzard and gall bladder and lets it hang over the back of the bird. After this one person each removes the heart, liver and gizzard. These then follow a separate movement path. The first two are immediately washed and sent for chilling. Gizzards are split, their contents washed off and their inner horny skin peeled off using a gizzard peeler. At 2000 BPH it is economical to automate the gizzard handling operations by the use of appropriate automatic machinery.

The washed and peeled gizzard then joins the other edible offal such as heart and liver for repacking into trussed birds or sale as separate items according to local market requirements.

The lung sucking pistol is positioned towards the end of the evisceration section. It is used by an operator to remove the lungs and any other debris, by application of vacuum. One person can use the lung sucking pistol on 1000 chicken per hour. Removal of trachea and crop is performed manually after evisceration.

If the dressed whole chicken are to be sold with neck off, then one person positioned along the line uses a pair of pneumatic scissors to chop off the necks. Also depending on local conditions the neck skin might need to be cut off. This is done manually with a knife. These operations can also be done after the birds leave the evisceration trough.

7.5 Bird Washing

Birds are passed through a locally fabricated outside-chicken spray wash. At 2000 BPH it is economical to use the more efficient washing option of the automatic inside-outside bird washer.

7.6 Hock Cutting and Unloading

After washing, carcasses are dropped into the spin chiller by cutting off the hocks (using pneumatic hock shears in very small plants or using a hock cutter in 1000 BPH upwards capacities).

In very small plants it is usual to position another person along the line to pull off the remaining hocks from the shackles. At 1000 BPH upwards, it is usual to automate the slaughter by using an automatic hock unloader. The line then passes through a shackle washer.

In plants larger than 1000 BPH, it is usual to split the overhead conveyor into two parts - one each for the killing and evisceration areas. In such instances the hock cutter is positioned at the end of the killing line and the birds are re-hung manually onto the evisceration line by their hock joints.

7.7 Spin Chilling

Depending on line speed, carcass size and cooling water temperature, the carcass is allowed to remain in the spin chiller for approximately 25-30 minutes or more. Here, by using a counter-current chilling configuration, assisted by compressed air bubbling in the water to allow improved contact with the carcass, chilling of the carcasses is done till they are approximately 6 degrees C or lower. The spin chilling action also performs a thorough internal and external washing of the birds. Approximately 2.5 litres of water should be used per kilogram of carcass. Water is pre-chilled to as close to freezing point as possible, and depending on line capacity and spin chiller size, flake ice may be added to the water to assist rapid chilling.

Quality of carcass can be retained only if thorough chilling is done AS SOON AS POSSIBLE after killing. It is therefore essential to have as low a water temperature as possible in the chiller.

7.8 Dewatering, Weighing and Batching

After chilling, birds are automatically unloaded from the chiller by the integral windmill unloader. The next action is to remove excess water. In small configurations, which do not aim in the foreseeable future to go in for automated weighing and grading using a computer system, a spin water extractor called a rumbler is used. Else a drip line is installed which can later be retrofitted with equipment for weighing and grading using a computer. In very small operations it is also possible to extract excess water by tumbling birds onto drip racks or tables.

The overhead shackle-line main chain is automatically lubricated. The lubricator is an integral part of the system.

7.9 Offal Handling

Approximately 24.5% of the chicken's live weight is discharged as offal during killing, plucking and evisceration (assuming heart, liver, gizzard and neck are retained as edible giblets. Offal flows as slurry in the floor gutters and is automatically pumped and filtered. Blood is taken into a storage tank, while the feathers, removed at the plucking station, together with feet and head, are passed through a screen. The liquids are sent for effluent treatment while the solids are disposed off by converting into manure, rendering or sale to fish farmers. In some countries head, feet and blood are consumed and they must be handled hygienically for such use. Manual handling of offal in the process house is the surest way to downgrade your product hygiene.

7.10 Portioning and Packing

To obtain high quality de-boned meat it is important to mature the carcasses. After maturation the carcasses are portioned and then deboned. For small plants it is usual to have disc-cutters and cone-deboners for making the initial cuts and following up with manual de-boning/trimming and packing.

Giblets are inserted into the carcasses and birds meant to be sold as full frozen chicken are trussed. For this a bagging horn is used. An alternative to this is the automatic pneumatically operated bagging machine which can handle 700 birds an hour. After this, the un-bagged birds, meant to be sold as fresh chilled are packed with shell ice in crates while the bagged birds meant to be sold as frozen, are sent to the blast freezer.

8 Manpower

Estimate of total manpower requirement is given in the feasibility template. The manpower requirement can be seen to change depending on hours of operation and amount of portioning/deboning to be done. Because the product mix needs to change according to market requirements it is not possible to give any one figure for a plant size unless all these factors are known. The feasibility template calculates manpower to suit the need.

Bird catching at the farm sheds is done under dim light and birds are transported in the cool hours of the day to save them from heat stress. A standard truck transporting birds in cages moves approximately 1400 birds every trip. Men, as opposed to women, are better suited for bird catching and transport.

1. In plants where the transport conveyor for live chicken crates does not exist, two persons are available in the off-shift in the slaughtering section. They alternately unload bird crates from trucks and clean the plant using high pressure hoses.

2. In plants where the transport conveyor for live chicken crates does not exist, at the start of the main shift, one man takes up the crates (containing up to 14 birds each) and positions them conveniently for the bird hanger. For the rest of the time he attends to the crate washer. After that he washes the product crates.

3. One man is suitable for hanging the birds at 1000 BPH if the roller conveyor brings the crates just below the hanging section of the track. In these plants the conveyor moves in the opposite direction of the track. For 500 BPH, one man can perform without a roller conveyor for crates

4. One man (1000 BPH) performs manual killing either by halal or other manual methods.

5. One man is stationed in the scalding hall to attend to plucker and scalder. He also picks pin feathers in case required.

6. One man cuts the vent using the vent drill, achieving 1000 BPH

7. For every drill employed, one man enlarges the vent cut with a knife

8. For every knife cut, one man scoops out the pack using the evisceration fork

9. At 1000 BPH one woman removes the gall bladder

10. For every 1000 BPH one woman each cuts out the gizzard, liver and heart from the pack and drops the remaining pack into the trough and the edible offal into the giblet flumes

11. For every 1000 BPH two men cut the gizzard open and wash the insides and one operates the gizzard control table to peel gizzards. Alternatively, if you use automation only one attendant is required for the section.

12. For every 1000 BPH one woman slits the neck skin (if the market requires slit neck skin) and one man cuts off the neck using pneumatic neck shears (if the market requires neck removed)

13. For every 1000 BPH one man is required to pull the trachea and crop. (The manner in which Halal is performed can cause the trachea to remain in the carcass even after the bird passes the head puller).

14. Every 1000 BPH requires one man with lung sucker to remove the lungs

15. One man to cut the hocks and drop the carcasses into the screw chiller at approximately 500 BPH, in case this is done manually. Else using a hock cutter requires no human intervention.

16. One man to remove cut hocks from the shackles at approximately 500 BPH in case this is done manually. Else using a hock unloader requires no human intervention.

17. Six persons in the dripping and packing department for 1000 BPH. More in case weighing is performed manually. In that case the number depends on design of the weighing, batching and packing requirements etc as per your choice.

18. The number of persons required for portioning and deboning depends on your throughput and production programme. The feasibility template shows the change as you change the product mix.

19. One supervisor (who also acts as replacement for absent workers).

20. One electrical and one mechanical maintenance man.

21. Two or more men to handle refrigeration, blast freezing and transport of ice within the plant, depending on capacity, freezing requirements and plant layout.

9 Washing and Disinfection

Equipment washing is performed after each shift, after production, and removal of large, easily detachable parts. High pressure wash with plain water at 30-40 bar is used for removal of dirt. Foaming with an alkaline foaming detergent is then performed for a usual contact duration of 20 minutes or as specified by the manufacturer of the detergent. This is followed by a high pressure rinsing (up to 100 bar) to remove the detergent and residual dirt which should be loosened now. The last step is washing with a disinfectant and then rinsing to remove the disinfecting agent. Disinfection[6] is not a substitute for washing. If the machine is dirty, that dirt will continue to harbour microbes even after overdoses of disinfectant.

Depending on hardness of local water, a periodical acid cleaning is recommended. This can be once every two-three weeks. It removes deposits of calcium and magnesium salts and iron oxide. If disinfection is done using a quaternary ammonium salt (quat), it is necessary to use a chlorine type disinfectant once every week, to prevent bacteria developing resistance.

10 Design Considerations

10.1 Standards

Standards to be used when designing a plant are typically the Codex Alimentarius, The EU Standards, USDA Standards and others. To be able to conform to these standards great care must be exercised at the design stage itself for all civil and construction aspects and of course in selection of machinery.

10.2 Design Thumb-rules

Some broad guidelines for design of the building and general layout are given below.

The entire plant building can be built using a 6 metre grid of columns with beams below the ceiling (if using option (a) construction. The floor should have a slope of 0.5% (it is not comfortable for people to stand for long hours on slopes in excess of 1%) leading into floor gutters which will require to be built in all the slaughter rooms and all non-frozen refrigerated areas. Finished floor surface is best achieved with a high density, light coloured, acid-proof stone or vitreous tiles having a high degree of wet traction. Look around for a suitable rock in your own area. In India all these qualities are met very economically by Kota stone.

If you have plans for using chicken slaughtering machinery of global standards in the building, then the clear height in the slaughtering plant area from finished floor level to bottom of beams (or false ceiling if made of PU sandwich panels) should be 4.2 metres or more.

Except where you use insulated pre-formed panels, the walls have to be glazed up to around 2.5 metres and have plastic emulsion paint above the glazing. Use of epoxy in place of glazed wall tiles has been tried in India with very disappointing results. Avoid the use of paper lining, cloth, wood and asbestos in construction of slaughter and cold areas.

The construction standards discourage the use of underground gutters in the slaughter and refrigeration areas. All gutters need to be open with steel grid covers in sections of 1 metre or some such convenient lengths. These are removable, for easy cleaning. All gutters are either of 300 mm width or 600 mm width and slope at

0.5% or more towards the offal pit. Gutter bottoms are best made with a semi-circular profile - flat bottomed gutters are ineffective. Gutter covers may be painted or if possible, dip-galvanized after fabrication.

Wash basins/stands are located just inside the slaughter area at all doors with foot-dips at the doors. The wash stand should have elbow or knee operated taps. Bathrooms should not directly open into process areas.

For the refrigeration section it is important to have the same finished floor level as the slaughter area. This will prevent accidents. Refrigeration area floors where the temperature goes below freezing, should never have tiled or stone cobble floors. The best flooring is dewatered granolithic for such areas.

If refrigeration areas are to be built on a greenfields plot, consider an approximate height build-up of 600 mm comprising floor insulation, transverse anti-heave tubes or floor heaters, and suitable flooring. Ignoring the use of breathing tubes/floor heaters results in floor-heave and cracked floors with unsatisfactory hygiene.

For planning frozen storage area consider 650 Kg of chicken per sq metre. Consider 0.5 kg of ice per kg of chicken for shipment of fresh chilled product.

Calculate cold water requirement from this data: A 3 metre long, 1.6 metre dia screw chiller takes 2.8 m^3 of water per hour for 1000 BPH of average 1600 grams live weight each. It requires a 21 kW water cooling capacity in the refrigeration plant to generate cold water which can bring down the core temperature from +38^{o}C to +6^{o}C. By the addition of flake ice, the core temperature can be brought down further to +4^{o}C.

11 Future Growth and Diversification

The key to future growth and diversification is modularity of machinery.

a) Ascertain if the machine-ends can be unbolted and expanded by the simple expedient of adding more sections. This is typical of well designed conveyors, troughs, scalders, spin chillers, cone deboners, and overhead main conveyors.

b) Ascertain also if the overhead conveyor can be dis-assembled and re-configured into a changed layout without having to discard elements and without too much reworking.

c) Ascertain from the layout submitted to you if extensive changes in the building would be necessitated in the event you want to expand.

d) Ascertain whether the layout allows you to conveniently place advanced machinery like automatic evisceration machines or automatic weighing and grading machines without shutdowns.

e) These attributes are essential if you wish your business to grow. When you need to change the processing details or expand, you cannot take long shut-downs for modifying machinery or building.

A slaughter house is the first stepping-stone to further processing of chicken.

Initially the slaughterer sets up facility for portioning of chicken, and deboning of prime portions using manual methods. Next, as these volumes increase, the slaughterer may wish to go into ready-to-cook products like deboned meat, curry-cut, etc. Finally he prepares to offer ready-to-eat products such as formed products (cutlets, kebabs, nuggets, burgers, momos), stuffed products (salamis, sausages) or cuts (grilled chicken, wing tips, drummets) specifically fried/smoked/steamed.

However, designating the same premises for processing and further processing for ready-to-eat products is not acceptable – they should be in different or adjacent premises so that cross contamination does not occur..

[1] To remove feathers, the local butcher removes the skin immediately after bleeding. This is an essential step in wet market slaughter because the butcher owns neither a scalder nor a plucker and this is the only way he can conveniently remove feathers. Contrary to whatever claims the butcher or champions of the wet market may make, this method of removal of feathers is not a quality feature, rather it severely and immediately downgrades the product quality.

There is no process machinery available anywhere in the world for eviscerating birds after removing the skin. One important reason is that when death occurs, involuntary muscles like those around the cloacca relax, discharging volumes of faeces all around. If the skin is removed at this stage, the entire bacterial load spreads to the meat from where it is virtually impossible to dislodge. It pays to remember that skin is a protective layer, and even in death it continues to protect the meat.

[2] Ice-pack coolers are recyclable plastic sealed containers containing glycol. These are pre-frozen in a freezer and then put along with chicken in door delivery vans/pushcarts. Because of the large thermal capacity of glycol, these ensure low temperature of the product for a long time.

[3] A merchant facility is defined as one in which the slaughterer BUYS live birds from the open market and SELLS slaughtered products to the open market – his only value-addition being slaughtering and related activities.

[4] Finnish Expert Report on Best Available Techniques in Slaughterhouses and Installations for the Disposal or Recycling of Animal Carcasses and Animal Waste. Finnish Environment Institute, Helsinki 2002. ISBN 952-11-1076-1, ISBN 952-11-1077-5 (PDF), ISSN 1238-7312

[5] When slow-frozen carcasses are thawed, large amounts of drip issues out of them - significantly more than what issues out on thawing of quick frozen carcasses. Much of the available literature offers an amusing bit of misinformation as reason for this phenomenon - that slow freezing produces large ice crystals which puncture the cells to release water from confinement.

Slow freezing does indeed result in relatively larger ice crystals, but animal (muscle) cells are surrounded by cell membranes which are very flexible (as opposed to plant cells which have relatively rigid cell walls) and cannot easily be punctured by ice crystals. Moreover an intercellular ice crystal can only be approximately as large as the amount of free water inside a cell, and this amount, by definition, has to be significantly smaller than the volume of the cell.

Muscle protein is responsible for a very important property of meat - its ability to retain water and bind added water (water-holding capacity or WHC). Between 84-94% of the water in muscles is free water and this is what gives fresh meat its succulence. This water is not mechanically free as it would be, for instance, in a piece of rubber foam - rather it is bound within the myofibrillar spaces. When slow freezing causes changes in the overall pH, the process is irreversible and impacts the environment inside cells as well as outside. Both of which release water. this not only releases water from inside cells but also bound water and impacts the product taste rather adversely. When thawed, this denaturation water from comes out as excessive thawing loss - which is bad for the product's image.

[6] Henkel and Diversey Lever among others are possible sources of appropriate disinfection agents. Diversey can be reached at http://www.johnsondiversey.com or write to surendra.soni@johnsondiversey.com